

Correspondences between:
Nikola Tesla, William A. Anthony, Thomas Burton Kinraide, Dr. Frederick Finch Strong, Earle L. Ovington, Anabel Parker, Elihu Thomson, Robert Underwood Johnson. With additional notes on Thomas Stanley Curtis and John Ernest Worrell Keely.

Compiled by Jeff Behary of the
Turn of The Century Electrotherapy Museum.

Not for distribution. For Reference Only.



Dedicated to friends Frank Jones, John Grizzy, Dan Cuscela, Kelly McJilton, Bert Hickman, Daniel Davis, John Jenkins, Jeff Parisse, Robert Greenspan, Robert Campbell… And to the memories of: William C. Wysock, James Hardesty, Harry Goldman, Leland I. Anderson, and Dave Archer.

Endless thanks to Robert Campbell, Frank Jones, Dr. E. C. Krupp of Griffith Observatory, Leland I. Anderson, Andrew Wright, the Nikola Tesla Museum in Belgrade, Harry Goldman, and Thomas Curtis. Materials in this book were compiled from these sources and from the collection of the author.

HIGH-FREQUENCY CURRENTS

BY

FREDERICK FINCH STRONG, M.D.

Instructor in Electro-Therapeutics at Tuft's College
Medical School, Boston.

WITH 183 ILLUSTRATIONS IN THE TEXT

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A magazine article by *Tesla*, published in 1893, gave the writer his first idea of the nature and therapeutic possibilities of High-frequency Currents. *Tesla* reported his observations of the stimulating and vitalizing action of these Currents in the cases of several of his assistants, and upon his own organism. Although disclaiming any belief in the therapeutic value of the older forms of electricity then in use (Faradism, Galvanism, etc.), he professed himself as fully convinced of the important part that his High-frequency Currents of High Potential were destined to play in the Healing Art of the future. These facts were not considered at the time, as of more than passing interest, but were brought back to the writer's memory a few years later in a lecture on the X-Ray at the Massachusetts Institute of Technology, in which the methods for the generation of High-frequency Currents were explained, and demonstrated by a small coil of the *Thomson* type excited by the discharge of a battery of *Leyden* Jars charged by a *Ruhmkorff* Coil. There was at this time practically no literature on the subject, except a report of *Tesla's* lecture before the Royal Society of Electrical Engineers, in 1891.

Through the courtesy of *Dr. J. B. Sutherland*, at that time Professor of Anatomy at Boston University School of Medicine, the writer was given the use of his private laboratory for the purpose of carrying out investigations concerning *Roentgen's* newly discovered "X-Rays." His first work was done with a small three-inch spark coil, laboriously wound by hand, and a small *Crookes* tube obtained from *Queen & Co.* A few weeks' experience demonstrated the inadequacy of this apparatus for X-Ray work, and the construction of an eight-inch coil was under way when the above lecture was given at the Institute of Technology. This was the real beginning of the writer's investigations of High-frequency Currents, and his first "*Tesla* Coil" was completed simultaneously with his eight-inch *Ruhmkorff*. When primary batteries were used as a source of energy he found that the X-Rays from the latter coil were superior to those obtained from "the *Tesla*" and the latter was temporarily discarded for X-Ray work.

About this time the writer made the acquaintance of *Mr.*

T. B. Kinraide and witnessed at his laboratory in Jamaica Plain, a demonstration of X-Rays of such power as to render the bones of the trunk as clearly visible as those of the hand. Without doubt, *Mr. Kinraide* was the first investigator to produce rays of such high power, but his methods were so expensive and complicated as to greatly restrict the field of their application. A tremendous amperage was obtained from a large bank of storage cells, the current being interrupted by a heavy Platinum Break of *Mr. Kinraide's* invention. A *Ruhmkorff* coil, rated at about eight inches, was thus operated, the secondary terminals being connected with a condenser immersed in kerosene. This in turn was provided with a discharge circuit, consisting of a *Tesla-Thomson* Coil (immersed in oil), in series with a spark-gap. From the secondary of the High-frequency Coil, *Mr. Kinraide* derived the currents which he employed to excite his *Crookes* tube. Some months later he invented his well-known "*Kinraide* Coil," which superseded his original apparatus. At the suggestion of *Mr. Kinraide* the writer modified his own outfit, and adapted it for use on the 104 volt, 60 cycle, alternating, Electric Light Current, obtaining results far beyond his expectations. The only unsatisfactory feature of this apparatus was the spark-gap, which consisted of two electric light carbons mounted on an insulated support, and separated by a short air space. An air blast spark-gap, as suggested by *Prof. Elihu Thomson* increased the steadiness and efficiency of the discharge, but greatly complicated the apparatus. At this period, the *Knott* Apparatus Company, of Boston, brought out their "*Knott* High-frequency and X-Ray Apparatus," which was provided with a simple rotary spark-gap, consisting of a large metal disk, revolving in front of a brass ball. This device, we believe, was the invention of *Mr. E. Cate* of the *Knott* Company. The writer's rotary gap, employed in the "*Hercules*" Coil, is an improved and perfected form of *Mr. Cate's* device. The *Knott* Coil, which is described in an ensuing chapter, was the first American High-frequency apparatus placed on the market, and for years was the only successful coil of this kind in use for X-Ray work. With the addition of the *Knott* spark-gap, the writer's apparatus proved very satisfactory, and was subse-

Introduction

This is where my story begins. The year was 1995. I was collecting coffee grinders and espresso machines. Occasionally I would see some intriguing-looking contraptions labeled "medical quackery" or "quack medical device". One day I saw a man demonstrating one…it was generating miniature lightning bolts from the end of a blown-glass electrode. I was hooked. The device was a "Violet Ray" machine. I bought it for $35. Within a few years I had more than 100 of them... and although the new "internet" seemed to have knowledge about every topic, these weren't mentioned anywhere. I decided to document a side of history that appeared to have fallen through the cracks of time. This was to become my niche… and from there, 28 years later, I have a museum that documents 300 years' worth of similar forgotten technologies.

An inspiration to start the museum was acquiring a book from my friend and mentor Jim Hardesty. The book was called "High Frequency Currents" by Frederick Finch Strong. As it happens, Strong invented the glass electrodes for the Violet Ray machines. In his book he did something peculiar – he mentioned how he was inspired in the early days. This was not a common practice to divert from the usual subject matter in a medical book… but Strong was no typical doctor. As we learned decades later in acquiring a personal scrapbook of his, he thought so "outside-of-the-box" that he was nearly ostracized from the profession for some of his eccentric beliefs. But he did something else quite interesting. He documented a complete history of a branch of electrotherapeutics that was only a decade old. It seemed unusual, but in reality he was ensuring that he, his colleagues, and even his competitors received credit where credit was due. The branch of high frequency currents was taking over the country. Had he not done this many early manufacturers and pioneers of Tesla Coils would have disappeared into obscurity.

The late 1800s was a magical time. Edison's electric lamp forever changed the world. The average person barely grasped an understanding of this new force called "electricity". In 1891 a man named Nikola Tesla was lighting lamps without wires. It seemed a combination of magic, sorcery, and pure intrigue only heightened when Röntgen announced a new form of ray that could photograph the invisible. Kids were sending wireless messages using telegraphy… the sky was the limit for human inventiveness and possibility.

In as much as great innovation came from this time period, there was also a large plethora of people taking advantage of the lack of knowledge in these areas. By the 1920s quackery ran rampant across the United States.

The people mentioned in this book were the pioneers of high frequency coils used in the medical field:

Nikola Tesla and Elihu Thomson were early rival experimenters in alternating currents and high frequency currents. In Boston there was a lesser-known experimenter named Thomas Kinraide who was independently working along the same lines. He was experimenting with flat-wound high frequency coils which used solid insulation composed of beeswax and rosin. Like Tesla, he was fascinated with electrical discharge phenomena and took up photographing electricity directly onto photographic plates by the light of the sparks. I dreamed of finding some of these photographs after reading about them in a book my Samuel Howard Monell: *A System Of Instruction In X Ray Methods, Medical Uses Of Light, Hot Air, Vibration, And High Frequency Currents*.

In 2005 I ended up finding Mr. Kinraide's home in Jamaica Plain, Massachusetts after 10 years of research. It wasn't so much a home as a massive 25-room mansion. While there I discovered a series of hidden rooms in the basement and found relics that Strong described witnessing in the reminiscences of his 1908 book. Not only did I find Kinraide's glass photographs of electrical sparks, I also found his earliest prototype high frequency coils. It was the discovery of a lifetime for a historian. Even more rare than the electrical artifacts were glass-plate negatives depicting the fraud of an infamous invention known as "The Keely Motor". In 1875 John Worrell Keely announced a new type of motor that ran on a mysterious force, a new form of energy that only he knew the secrets of. He would hold elaborate séances to entice investors, and soon had a company worth millions of dollars that didn't product a single product. Kinraide was a close friend of Keely, and when the inventor Keely passed away unexpectedly on November 18, 1898, it was Kinraide who was left with the challenge of "continuing Keely's work". Kinraide found plain evidences of fraud in every Keely experiment, and setup the motor and various related gadgets in his laboratory to demonstrate the truth to Keely investors on agreement they would take their losses quietly and not expose the fraudulent genius. Kinraide wanted nothing to do with the scandal, and least of all to expose his friend and have him in a negative light post-mortem.

In spite of being thrust into the public eye at a time when he would have preferred to continue his X-Ray research, Kinraide recovered from the incident and his machines were amongst the most popular sold at the time. Originally constructed in his home under the name "Spring Park Laboratory", Kinraide partnered with Swett & Lewis, one of the earliest suppliers of Crookes and X-Ray tubes in Boston. His machines were being made under the supervision of an electrician named Howard Jackson. After a year of selling his machines, Kinraide did something unprecedented in the industry: He lowered the price from $200 to $130. The company announced that they sold so many machines within the first year of mass-production that they paid for all of the expensive tooling and molds invested to produce them, and wanted to share this success with the profession by making the machines more affordable.

Doing research on Frederick Strong proved more difficult. He never had kids, and it was seemingly hopeless that anything would show up. That all changed in 2014 when a personal scrapbook was purchased by a young man in Montana amongst a table of farm tools. He found mention of Strong on my website and sold it to me for $1000 firm. While I imagined Strong as being somewhat eccentric, the scrapbook proves it beyond a doubt. It is a terribly interesting read on many levels.

The story of Earle Ovington is also quite unique. I learned that Earle's daughter ran a pub in Santa Monica, but when I reached them by phone I learned I was a year too late – that she had already passed away. They put me in touch with a historian that was compiling a book on Ovington – Robert Campbell. Bob was about to give up on a book he spent nearly a decade writing after every publishing company turned him down. After some encouragement from Frank and I, Bill Wysock, Harry Goldman, and Richard Mathias he decided to self-publish and created *Reminiscences of a Birdman*, a unique biography of a young man from MIT who worked for Edison, befriended Tesla, and became a well-known pilot who delivered the first airmail in the United States, as well as sending and receiving the first wireless messages from ground-to-plane. Earle was a natural entrepreneur, whose career included making Tesla Coils and X-Ray machines, importing motorcycles, pioneering aircraft safety measures, modular housing, and the idea for the first "airport". He worked as an assistant to Thomas Edison for several years.

As collectors, we always speculated that Tesla must have met or corresponded with some of these people at various points in time. It wasn't until receiving documents from the Nikola Tesla Museum in Belgrade that we had solid proof. In addition to this we know that Tesla kept extensive files of these individual's patents. To my surprise, I could find no correspondences of Tesla and Thomas Stanley Curtis. Curtis, while only a teenage boy, wrote one of the most comprehensive texts on Tesla Coil construction ever compiled. He lived in New York City and sold subcomponents to hobbyists interested in high frequency. We can speculate that they must have known each other, but until evidence shows up there is no hard evidence. I include some letters from Thomas Adams ("Tad") Curtis who reached out to me while researching his father's work in 2007. He was writing a book with his brother about their Dad, but sadly I don't think it ever materialized. He was in his 80s in 2007.

Other people to mention include Kenneth Strickfaden of Frankenstein movie fame. He worked for John Foster at Universal Studios with apprentice Dick Aurandt. Ken created hundreds of high voltage gizmos for science fiction and horror films of the 1930s-70s. He also travelled to schools and put on high voltage events involving arcs, sparks, and theatrics.

Harry Goldman was friends with Ken. Harry formed the Tesla Coil Builders Association, an early newsletter of Tesla Coil construction techniques and articles that were published long before the internet.

Bill Wysock was also inspired by Kenneth Strickfaden. Bill created commercial Tesla Coils for 50 years, many of which were used in Hollywood productions. His company was Tesla Technology Research.

Another important name is Jeff Parisse. In 1996, he founded kVA Effects, a high voltage special effects company that uses Tesla coils to make electrical arcs for entertainment. His television appearances include History Channel's Modern Marvels (Mad Electricity), SiFi Science (Argon Cannon) and a two year run on NBC's Fear Factor where he developed the show's most popular game (Lightning Bridge).

Leland I. Anderson was a lifelong Tesla historian. He began collecting and saving original Tesla memorabilia starting in 1943 and amassed one of the largest collections of Tesla paperwork and photographs in the world.

Jim Hardesty was another important historian, collector and master craftsman. His specialties included antique static electric machines, crystal radios, induction coils, wireless telegraphy, and vacuum discharge tubes.

I couldn't have done much of this work without encouragement from collector friends such as Frank Jones, Dan Cuscela, John Grizzy, Kelly McJilton, Robert Greenspan, and John Jenkins. The Tesla community has some real gems as well, including electrical discharge and lightning experts Bert Hickman and Daniel Davis…

And last, but not least: Dave Archer. Dave was an incredible artist and friend who passed away just recently. He was a true legend, and created electric space art using Tesla Coils. His son Forrester is carrying on the tradition. His paintings are in the collections of people ranging from Buzz Aldrin to Hugh Hefner.

TESLA'S STARTLING RESULTS IN RADIOGRAPHY AT GREAT DISTANCES THROUGH CONSIDERABLE THICKNESSES OF SUBSTANCE.

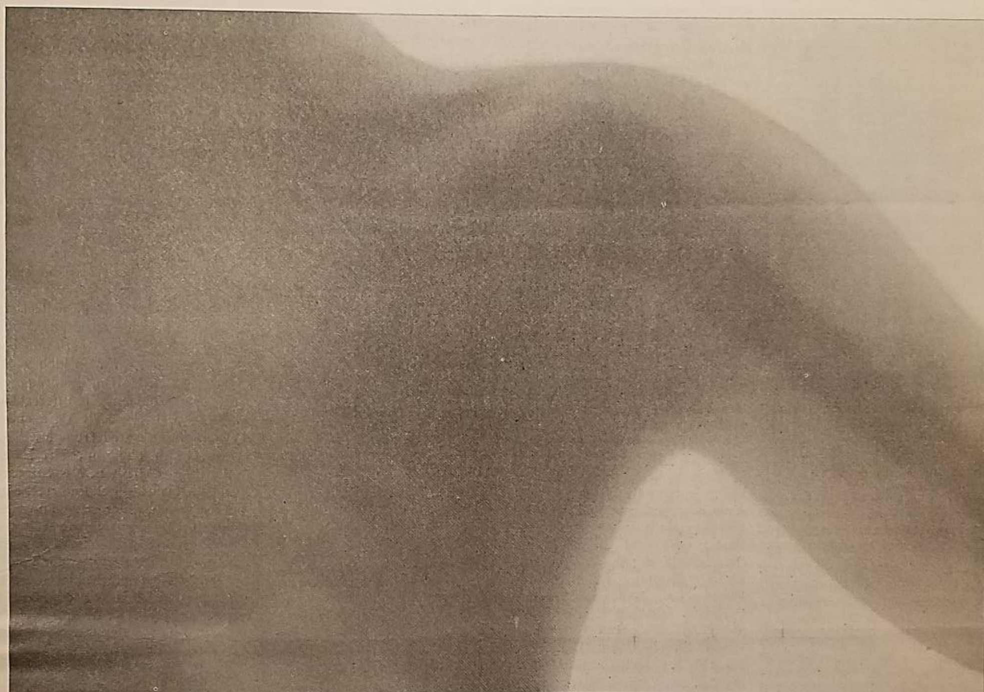


FIG. 1.—PHOTO-ENGRAVING OF TESLA RADIOGRAPH OF RIGHT SHOULDER OF A MAN, SHOWING RIBS AND SHOULDER AND UPPER ARM BONES—TAKEN THROUGH CLOTHING, BOARD, ETC., AT A DISTANCE OF FOUR FEET.

TESLA ON ROENTGEN RAYS.

A HIGHLY INTERESTING AND VALUABLE COMMUNICATION FROM THE TALENTED YOUNG INVENTOR.

TO THE EDITOR OF ELECTRICAL REVIEW:

One can not help looking at that little bulb of Crookes' with a feeling akin to awe, when he considers all that it has done for scientific progress—first, the magnificent results obtained by its originator; next, the brilliant work of Lenard, and finally the wonderful achievements of Roentgen. Possibly it may still contain a grateful Asmodeus, who will be let out of his narrow prison cell by a lucky student. At times it has seemed to me as though I myself heard a whispering voice, and I have searched eagerly among my dusty bulbs and bottles. I fear my imagination has deceived me, but there they are still, my dusty bulbs, and I am still listening hopefully.

After repeating Professor Roentgen's beautiful experiments, I have devoted my energies to the investigation of the nature of the radiations and to the perfecting of the means for their production. The following is a brief statement which, I hope, will be useful, of the methods employed and of the most notable results arrived at in these two directions.

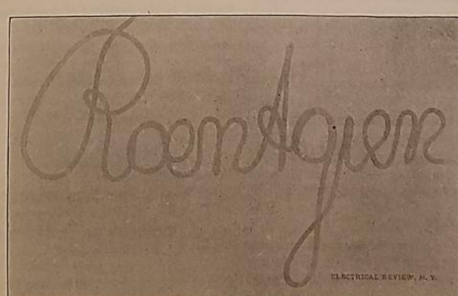


FIG. 2.—TESLA'S RESPECTS TO PROF. ROENTGEN—A RADIOGRAPH OF A WIRE SIGN TAKEN THROUGH A WOODEN COVER AT THE REMARKABLE DISTANCE OF ELEVEN FEET, WITH ONE-HALF HOUR'S EXPOSURE.

In order to produce the most intense effects we have first to consider that, whatever their nature, they depend necessarily on the intensity of the cathode streams. These again being dependent on the magnitude of the potential, it follows that the highest attainable electrical pressure is desirable.

To obtain high potentials we may avail ourselves of an ordinary induction coil, or of a static machine, or of a disruptive discharge coil. I have the impression that most of the results in Europe have been arrived at through the employment of a static machine or Ruhmkorff coil. But since these appliances can produce only a comparatively small potential, we are naturally thrown on the use of the disruptive discharge coil as the most effective apparatus. With this there is practically no limit to the spark length, and the only requirement is that the experimenter should possess a certain knowledge and skill in the adjustments of the circuits, particularly as to resonance, as I have pointed out in my earlier writings on this subject.

After constructing a disruptive coil suitable for any kind of current supply, direct or alternating, the experimenter comes to the consideration as to what kind of bulb to employ. Clearly, if we put two electrodes in a bulb, or use one inside and another outside electrode, we limit the potential, for the presence not only of the anode but of any conducting object has the effect of reducing the practicable potential on the cathode. Thus, to secure the result aimed at, one is driven to the acceptance of a single electrode bulb, the other terminal being as far remote as possible.

Obviously, an inside electrode should be employed to get the highest velocity of the cathode streams, for the bulbs without inside terminals

(Continued on page 134.)

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TESLA'S RADIOGRAPHS.

We publish a welcome addition to the Roentgen ray literature. It is from the always interesting pen of Nikola Tesla, and is the first authorized description of the experiments of this thorough and conscientious inventor. Mr. Tesla gives full credit to the discovery by Roentgen, and is personally much elated over discoveries of his own as his careful experiments are developed. The Tesla radiographs we present show wonderful results under severe conditions. While Tesla has heretofore been silent since the announcement by Roentgen, he has not been idle, but has evidently been striving for valuable and tangible results. Further information from his laboratory will be awaited with interest.

DECISION ON A VAN DEPOELE RAILWAY PATENT.

An interesting and important decision has just been rendered by Judge Townsend, of the United States Circuit Court for the district of Connecticut, upon the Van Depoele patent No. 495,443, for the underrunning electric railway trolley system. A few months ago Judge Townsend rendered a decision sustaining the validity of this patent upon final hearing in a suit against the Winchester Avenue Railroad Company. Shortly thereafter further infringement suits were brought in Connecticut against the Billings & Spencer company, of Hartford, and the Kelsey Electric Railway Specialty Company, of New Haven. Judge Townsend has just decided these suits in favor of the Van Depoele patent, and granted motions for preliminary injunctions after full argument on both sides. The decision is especially important because the court holds that the supply of essential or characteristic parts of the trolley system is a contributory infringement, and will be enjoined by the courts, even though the defendants may not supply or use the patented combination or system in its entirety. The court further held that an unlicensed maker of trolley bases could not be permitted to supply such bases even to railroads which had been originally fully equipped by the General Electric Company, the present owner of Van Depoele patent No. 495,443.

TESLA ON ROENTGEN RAYS.

(*Concluded from page 131.*)

are much less efficient for this special object in consequence of the loss through the glass. A popular error seems to exist in regard to the concentration of the rays by concave electrodes. This, if anything, is a disadvantage. There are certain specific arrangements of the disruptive coil and circuits, condensers and static screens for the bulb, on which I have given full particulars on previous occasions.

Having selected the induction apparatus and type of bulb, the next important consideration is the vacuum. On this subject I am able to make known a fact with which I have long been acquainted, and of which I have taken advantage in the production of vacuum jackets and all sorts of incandescent bulbs, and which I subsequently found to be of the utmost importance, not to say essential, for the production of intense Roentgen shadows. I refer to a method of rarefaction by electrical means to any degree desirable, far beyond that obtainable by mechanical appliances.

Though this result can be reached by the use of a static machine as well as of an ordinary induction coil giving a sufficiently high potential, I have found that by far the most suitable apparatus, and one which secures the quickest action, is a disruptive coil. It is best to proceed in this way: The bulb is first exhausted by means of an ordinary vacuum pump to a rather high degree, though my experiences have shown that this is not absolutely necessary, as I have also found it possible to rarefy, beginning from low pressure. After being taken down from the pump, the bulb is attached to the terminal of the disruptive coil, preferably of high frequency of vibration, and usually the following phenomena are noted. First, there is a milky light spreading through the bulb, or possibly for a moment the glass becomes phosphorescent, if the bulb has been exhausted to a high degree. At any rate, the phosphorescence generally subsides quickly and the white light settles around the electrode, whereupon a dark space forms at some distance from the latter. Shortly afterward the light assumes a reddish color and the terminal grows very hot. This heating, however, is observed only with powerful apparatus. It is well to watch the bulb carefully and regulate the potential at this stage, as the electrode might be quickly consumed.

After some time the reddish light subsides, the streams becoming again white, whereupon they get weaker and weaker, wavering around the electrode until they finally disappear. Meanwhile, the phosphorescence of the glass grows more and more intense, and the spot where the stream strikes the wall becomes very hot, while the phosphorescence around the electrode ceases and the latter cools down to such an extent that the glass near it may be actually ice-cold to the touch. The gas in the

bulb has then reached the required degree of rarefaction. The process may be hastened by repeated heating and cooling and by the employment of a small electrode. It should be added that bulbs with external electrodes may be treated in the same way. It may be also of interest to state that under certain conditions, which I am investigating more closely, the pressure of the gas in a vessel may be augmented by electrical means.

I believe that the disintegration of the electrode, which invariably takes place, is connected with a notable diminution of the temperature. From the point on, when the electrode gets cool, the bulb is in a very good condition for producing the Roentgen shadows. Whenever the electrode is equally, if not hotter than the glass, it is a sure indication that the vacuum is not high enough, or else that the electrode is too small. For very effective working, the inside surface of the wall, where the cathode stream strikes, should appear as if the glass were in a fluid state.

As a cooling medium I have found best to employ jets of cold air. By this means it is possible to operate successfully a bulb with a very thin wall, while the passage of the rays is not materially impeded.

I may state here that the experimenter need not be deterred from using a glass bulb, as I believe the opacity of glass as well as the transparency of aluminum are somewhat exaggerated, inasmuch as I have found that a very thin aluminum sheet throws a marked shadow, while, on the other hand, I have obtained impressions through a thick glass plate.

The above method is valuable not only as a means of obtaining the high vacua desired, but it is still more important, because the phenomena observed throw a light on the results obtained by Lenard and Roentgen.

Though the phenomenon of rarefaction under above conditions admits of different interpretations, the chief interest centers on one of them, to which I adhere—that is, on the actual expulsion of the particles through the walls of the bulb. I have lately observed that the latter commences to act properly upon the sensitive plate only from the point when the exhaustion begins to be noticeable, and the effects produced are the strongest when the process of exhaustion is most rapid, even though the phosphorescence might not appear particularly bright. Evidently, then, the two effects are closely connected, and I am getting more and more convinced that we have to deal with a stream of material particles, which strike the sensitive plate with great velocities. Taking as a basis the estimate of Lord Kelvin on the speed of projected particles in a Crookes' bulb, we arrive easily by the employment of very high potentials to speeds of as much as a hundred kilometres a second. Now, again, the old question arises: Are the particles from the electrode or from the charged surface generally, including the case of an external electrode, projected through the glass or aluminum walls, or do they merely hit the inner surface and cause particles from the outside of the wall to fly off, acting in a purely mechanical way, as when a row of ivory balls is struck? So far, most of the phenomena indicate that they are projected through the wall of the bulb, of whatever material it may be, and I am seeking for still more conclusive evidence in this direction.

It may not be known that even an ordinary streamer, breaking out suddenly and under great pressure from the terminal of a disruptive coil, passes through a thick glass plate as though the latter were not present. Unquestionably, with such coils pressures are practicable which will project the particles in straight lines even under atmospheric pressure. I have obtained distinct impressions in free air, not by streamers, as some experimenters have done, using static machines or induction coils, but by actual projection, the formation of streamers being absolutely prevented by careful static screening.

A peculiar thing about the Roentgen rays is that from low frequency to the highest obtainable there seems to be no difference in the quality of the effects produced, except that they are more intense when the frequency is higher, which is very likely due to the fact that in such case the maximum pressures on the cathode are likewise higher. This is only possible on the assumption that the effects on the sensitive plate are due to projected particles, or else to vibrations far beyond any frequency which we are able to obtain by means of condenser discharges. A powerfully excited bulb is enveloped in a cloud of violet light, extending for more than a foot around it, but outside of this visible phenomenon there is no positive evidence of the existence of waves similar to those of light. On the other hand, the fact that the opacity bears some proportion to the density of the substance speaks strongly for material streams, and the same may be said of the effect discovered by Prof. J. J. Thomson. It is to be hoped that all doubts will shortly be dispelled.

A valuable evidence of the nature of the radiations and progress in the direction of obtaining strong impressions on the plate might be arrived at by perfecting plates especially sensitive to mechanical shock or impact. There are chemicals suitable for this, and the development in this direction may lead to the abandonment of the present plate. Furthermore, if we have to deal with streams of material particles, it seems not impossible to project upon the plate a suitable substance to insure the best chemical action.

With apparatus as I have described, remarkable impressions on the plate are produced. An idea of the intensity of the effects may be gained when I mention that it is easy to obtain shadows with comparatively short exposures at distances of many feet, while at small distances and with thin objects, exposures of a few seconds are practicable. The annexed print is a shadow of a copper wire projected at a distance of 11 feet through a wooden cover over the sensitive plate. This was the first shadow taken with my improved apparatus in my laboratory. A similar impression was obtained through the body of the experimenter, a plate of glass, nearly three-sixteenths of an inch thick, a thickness of wood of fully two inches and through a distance of about four feet. I may remark, however, that when these impressions were taken, my apparatus was working under extremely unfavorable conditions, which admitted of so great improvements that I am hopeful to magnify the effects many times.

The bony structure of birds, rabbits and the like is shown within the least detail, and even the hollow of the bones is clearly visible. In a plate of a rabbit under exposure of an hour, not only every detail of the skeleton is visible, but likewise a clear outline of the abdominal cavity and the location of the lungs, the fur and many other features. Prints of even large birds show the feathers quite distinctly.

Clear shadows of the bones of human limbs are obtained by exposures ranging from a quarter of an hour to an hour, and some plates have shown such an amount of detail that it is almost impossible to believe that we have to deal with shadows only. For instance, a picture of a foot with a shoe on it was taken, and every fold of the leather, trousers, stocking, etc., is visible, while the flesh and bones stand out sharply. Through the body of the experimenter the shadows of small buttons and like objects are quickly obtained, while with an exposure of from one to one and a half hour the ribs, shoulder-bones and the bones of the upper arm appear clearly, as is shown in the annexed print. It is now demonstrated beyond any doubt that small metallic objects or bony or chalky deposits can be infallibly detected in any part of the body.

An outline of the skull is easily obtained with an exposure of 20 to 40 minutes. In one instance an exposure of 40 minutes gave clearly not only the outline, but the cavity of the eye, the chin and cheek and nasal bones, the lower jaw and connections to the upper one, the vertebral column and connections to the skull, the flesh and even the hair. By exposing the head to a powerful radiation strange effects have been noted. For instance, I find that there is a tendency to sleep and the time seems to pass away quickly. There is a general soothing effect, and I have felt a sensation of warmth in the upper part of the head. An assistant independently confirmed the tendency to sleep and a quick lapse of time. Should these remarkable effects be verified by men with keener sense of observation, I shall still more firmly believe in the existence of material streams penetrating the skull. Thus it may be possible by these strange appliances to project a suitable chemical into any part of the body.

Roentgen advanced modestly his results, warning against too much hope. Fortunately his apprehensions were groundless, for, although we have to all appearance to deal with mere shadow projections, the possibilities of the application of his discovery are vast. I am happy to have contributed to the development of the great art he has created.

NIKOLA TESLA.

New York, March 7, 1896.

Hudson River Telephone Company.

At the annual meeting of the stockholders of the Hudson River Telephone Company, which was held at the office of the company in Albany, N. Y., on Thursday, March 5, the old board of directors was re-elected, as follows: Joseph P. Davis, New York city; James Bigler, Newburgh, N. Y.; Selden E. Marvin, Albany, N. Y.; David B. Parker, Randolph, N. Y.; Henry L. Storke, Auburn, N. Y.; C. Jay French, Boston, Mass.; John E. Hudson, Boston, Mass.; James H. Manning, Albany, N. Y.; D. Cady Herrick, Albany, N. Y.

The report of the operations of the company for the year shows a gratifying increase in business and in net profits, although the average rate to subscribers has been considerably reduced. Several new exchanges have been added and there has been a net gain in subscribers' stations of 816 over the previous year. This is about 22 per cent, and the gain in metallic circuit subscribers has been 41 per cent. Nearly $80,000 has been expended from the earnings for the maintenance and betterment of the plant, and, notwithstanding this large investment, the net results for the year equal nearly five per cent on the outstanding capital of the company.

At a meeting of the directors, held immediately after the stockholders' meeting, the following officers were re-elected: President, Selden E. Marvin; vice-president, James H. Manning; secretary and auditor, Walter B. Butler; treasurer, James J. Fitzsimmons; general manager, Henry E. Hawley.

An Electric Light Company Loses Two Officers.

Stephen Powell, a leading and wealthy citizen of Hempstead, L. I., was murdered within 50 feet of his home last Saturday night. He was superintendent of the Hempstead Gas and Electric Light Company, besides having other important business interests. Mr. Powell always carried large sums of money in his pockets, and it is supposed that some one who knew this killed him, as most of the money he was known to have with him was taken. He was struck in the back of the head with an ax and was found lying in the street near his home. Two arc lights were burning within 400 feet of where he lay. Only a few days before this, Mayor Philip J. A. Harper, president of the Hempstead Gas and Electric Light Company, died.

A Parlor Car Trolley Ride.

President H. M. Littell, of the Atlantic avenue line, Brooklyn, took a party of Montauk club members on the beautiful parlor car "Montauk" to Coney Island on Saturday of last week. The trip began and ended at the Montauk Club. There were about 20 aboard. With music and refreshments the trip was hugely enjoyed. In the party were Messrs. Littell, Keating, Callahan, Candee, Snell, Berri, Price, Williams, Adams and Major Evans.

EDWARD P. THOMPSON, M. E.,
Solicitor of Patents.

PROF. WILLIAM A. ANTHONY,
Electrical and Scientific Expert.

ALFRED C. COURSEN,
Counselor-at-Law.

U.S. and Foreign Patents.

Patent Suits.

Interference Cases.

Trademarks, Assignments, &c.

Opinions on Patentability, Infringement and Practicability, &c.

Electrical Engineering Specifications.

Working and Patent Drawings.

Electrical Specifications for Architects.

Cable Address,

"SCIENCE, New York."

MAIN OFFICE:

New York, Temple Court,
Cor. Nassau & Beekman Sts.,
near
Post Office.

BRANCH OFFICE:
WASHINGTON:
Atlantic Building,
near Patent Office.

ADDRESS:
5 Beckman St., New York.
Dictated to: K. W. E.

March 6, 1896.

MR. NICOLA TESLA.

City.

My Dear Mr. Tesla.

It seems that you sent a gentlemen here to solicit an article for the Harpers Round Table, on the Roentgen rays. After some demur I consented to undertake to write something for him, and now I want something in the way of illustrations.

If you have photographs you have taken, something out of the common order, - not merely bones of the hand, but something a little more novel than that would be now, would you be willing to let me use them, of course giving due credit for them in the article. If you have anything of the sort would you kindly send me three or four or about 1/2 a dozen, from which I can select?

Very truly yours.

Wm. A. Anthony.

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March 13, 1896.

MR. NICOLA TESLA.
New York City.

My Dear Mr. Tesla.

Thank you for your kind offer to help me out with cuts for the Roentgen Ray article. I hardly know how to describe what I would like.

I suppose that you might have a number of photographs that you have taken by way of experiment, any of which would be interesting.

The Round Table people wanted something out of the ordinary line, that had not been published elsewhere.

Almost anything would answer the purpose.

It will be better perhaps if you can give me ten or fifteen minutes sometime, when I could call at your laboratory and see what you have that you would be willing that I should use.

I know how busy you are and I should not need to occupy much of your time.

I agreed to have the copy of the cuts in not later than the 21st, and the copy of the article not later than Monday or Tuesday, the 23rd or 24th.

Very truly yours.

Wm. A. Anthony

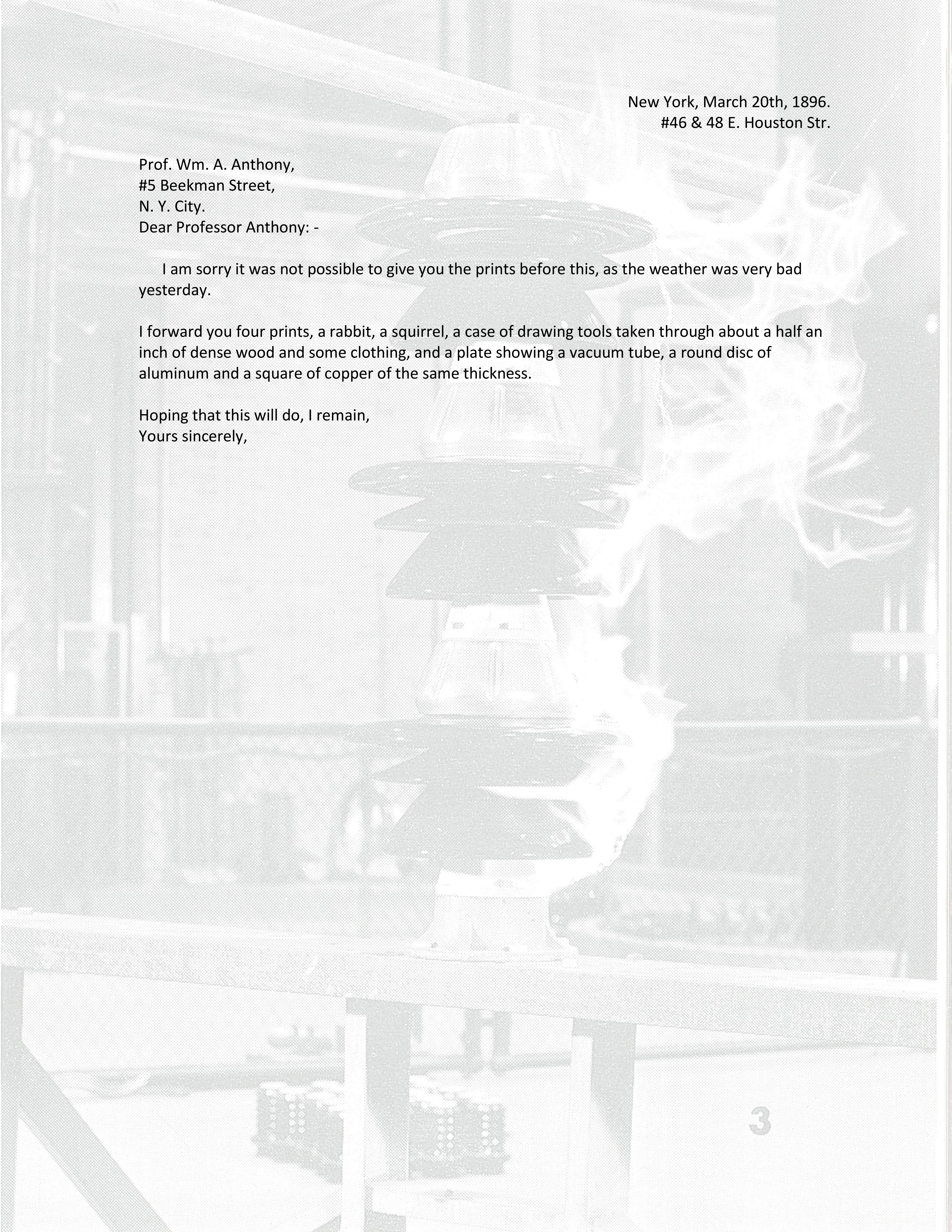
New York, March 16th, 1896.
#46 & 48 E. Houston Str.

Prof. Wm. A. Anthony,
#5 Beekman Str.,
N. Y. City.
My dear Prof. Anthony: -

Your letter was received in due course, but oscillators and Roentgen waves prevented me from replying before this.

I shall anticipate the pleasure of seeing you here any time you choose. The most convenient time for me is between 3 and 4 o'clock in the afternoon, but you may suit your own convenience.

Yours very truly,



New York, March 20th, 1896.
#46 & 48 E. Houston Str.

Prof. Wm. A. Anthony,
#5 Beekman Street,
N. Y. City.
Dear Professor Anthony: -

I am sorry it was not possible to give you the prints before this, as the weather was very bad yesterday.

I forward you four prints, a rabbit, a squirrel, a case of drawing tools taken through about a half an inch of dense wood and some clothing, and a plate showing a vacuum tube, a round disc of aluminum and a square of copper of the same thickness.

Hoping that this will do, I remain,
Yours sincerely,

EDWARD P. THOMPSON, M. E.,
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Dictated to: K. W. E.

March 24, 1896.

MR. NICOLA TESLA.
City.

My Dear Mr. Tesla.

I found the pictures Saturday morning and took them at once to Harpers. They were in ample time. What magnificent pictures they were. How can I show you my appreciation for your kindness?

I have been thinking over the reflection from the inside of the glass tube. It is certain that theoretically the effect at the end should be uniformly distributed even though the source were a mathematical point.

Let S be the source, and A' B' the tube. A A' the sensitive plate. S will have an image in the form of a ring of twice the diameter of the tube. S' S'' will be two elements of that ring. Rays [N. T. -2-] [illegible] [N. T. -3-]

I[n] other words the question is, will the rays start from the end of the tube in a vacuum as in air. Another sensitive plate might be placed at b.

The vacuum tube might be surrounded with copper down to the supplementary tube.

Very truly yours.
Wm. A. Anthony

ADDRESS:
5 Beekman St., New York.

Dictated to K. W. E.

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March 24, 1896.

MR. NICOLA TESLA.

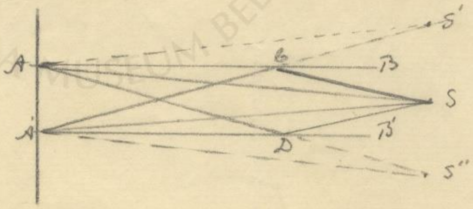
City.

MUZEJ NIKOLE TESLE

My Dear Tesal:--

I found the pictures Saturday morning and took them at once to Harpers. They were in ample time. What magnificent pictures theyw ere. How can I show you my appreciation of your kindness?

I have been thinking over the reflection from the inside of a glass tube. It is certain that theroretically the effect at the end should be uniformly distributed even though the source were a mathematical point.

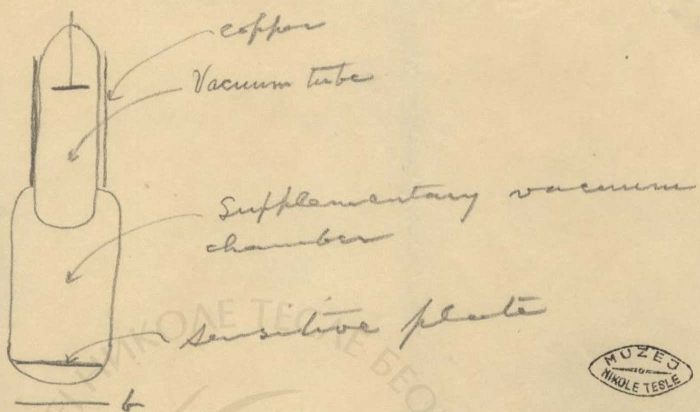


Let S be the source, and A.B., A'B' the tube. A A' the sensitive plate. S will have an image in the form of a ring of twice the diameter of the tube. S'S''will be two elements of that ring. Rays

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N. T. -3-



MUZEJ NIKOLE TESLE

I other words the question is, will the rays start from the end of the tube in a vacuum as in air. Another sensitive plate might be placed at b.

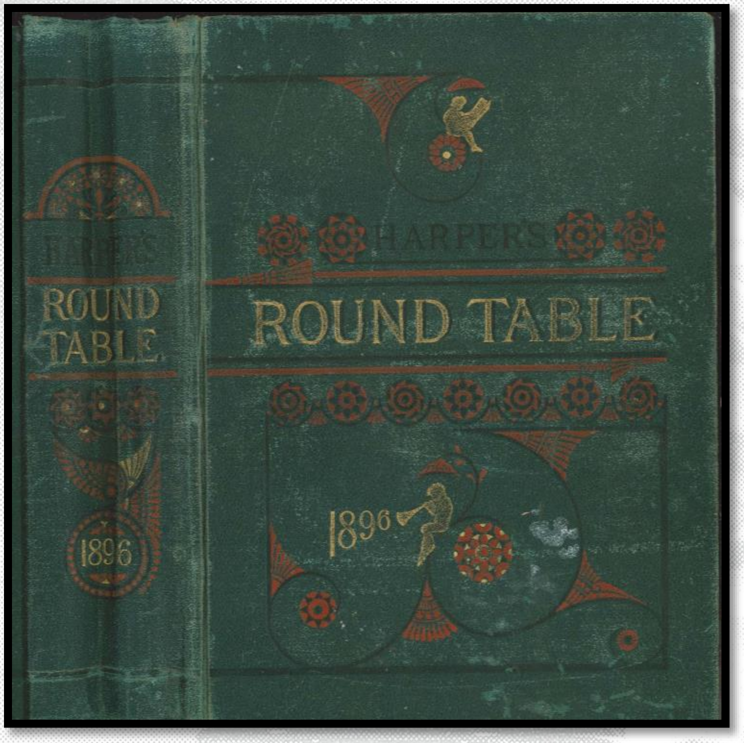
The vacuum tube might be surrounded with copper down to the supplementary tube.

Very truly yours.

Wm. A. Anthony.

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here I stays. An' the previous part o' my perceedins I'll tell ye some other day, but jes now I'd like to see your mother an' ask her ef she's forgot how I like her coffee."

RÖNTGEN RAYS.

BY WILLIAM A. ANTHONY.

IT is now some two months since the public was startled by the announcement that Röntgen of Bavaria had discovered that electric discharges in certain vacuum tubes, that is, tubes from which the air has been exhausted, gave out rays that would pass through wood, card-board, flesh, and numerous other substances opaque to light—that is, through which light would not pass, and would then affect the sensitive plates used in photographing, making it possible to show upon the plates the outlines of objects entirely hidden from the eye.

Probably what most aroused the interest of the public was the fact that when a structure, like the hand, was interposed in the path of these rays, the bones would cast a deep shadow, while the shadow cast by the flesh was very faint. It was thus possible to photograph the bones of the living body, and, of course, to show the presence of foreign substances or abnormal growths.

What has excited most surprise, perhaps, is the fact that these rays pass through bodies that are generally considered opaque, for it seems to those not familiar with the facts and demonstrations of science a most surprising thing that any rays should go through wood planks or sheets of metal or living flesh or brick walls. But is it really any more wonderful than that rays of light should go through glass or quartz or diamond or water? We are familiar with this last fact, because we can "see through" these substances. We know that glass does not shut out light, because we can *see* the space beyond it illuminated. But we have no sense that tells us of the presence of the Röntgen rays. We must resort to the photographic plate or the fluorescent screen (to be described further on), to show their presence, and for all information as to their behavior. The photographic plate is affected, while our eyes are not, and we are obliged to let such plates take the place of our eyes, and receive impressions which we can afterwards interpret.

575

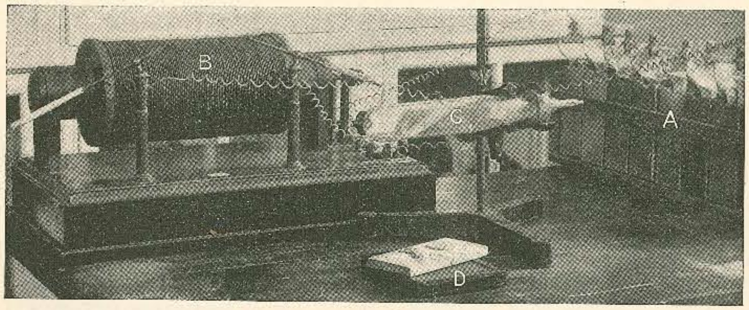


FIG. 1.—THE APPARATUS USED IN MAKING RÖNTGEN RADIOGRAPHS.

But what are "rays"? When we stand in front of a fire of glowing coals we *feel* the warmth, and our eyes tell us of the light. Light and heat are said to *radiate* from the glowing coals, and both light and heat proceed in straight lines. These straight paths followed by radiations we have called rays. These rays are quivering motions in a medium which we call the ether, and which we believe extends through all space and pervades all bodies. They are waves, having the character of waves on the water, which we can see, and sound waves in air, which we know exist.

These ether waves, those that affect the eye and those which do not, differ from each other, as all wave motions differ, in the distance from wave to wave, or what is the same, in the frequency of the vibratory motions. As an example, compare the long ocean swell that comes thundering upon the beach at intervals of several seconds with the frequent swash, swash, swash of the little ripples on the shore of a fish-pond, or the vibrations that can be felt as a tremor of the whole church when the deep bass pipes of the great organ are sounded with the sharp shrill tones of the high treble pipe.

There are means of measuring the distances from wave to wave of the different rays in the ether, and the result is astounding. The frequency is something of which it is impossible to form any conception. About 20 millions of millions per second is the lowest, and about 1000 millions of millions the highest frequency. Of these, those only which lie between 400 and 760 millions of millions per second excite vision. In other words, the ether waves breaking upon the optic nerve must come at the rate of at least 400 millions of millions per second before that nerve will carry any impression to the brain—before we can "see" them. Why rays of these frequencies only should affect the eye we do not know. We only know that the structure of the eye is such that the other rays are powerless to produce vision. Neither do we know why the low-frequency rays will go through hard rubber and will not go through glass. We only know it is a fact.

All these ether rays may produce heat. The high-frequency rays affect the photographic sensitive plate, and also produce another effect that is of especial interest in connection with the study of the Röntgen rays. They have the power of exciting a peculiar luminosity, or light, in certain substances, which are for that reason called fluorescent.

Electrical discharges in vacuum tubes have long been known as sources of radiations which produce heat and affect the eye. Every student of physics knows the experiment with the aurora tube, which, when exhausted by a good air-pump and connected to a Holtz machine or induction coil, is seen filled with a pale light having something the appearance of the streamers of the Aurora Borealis.

Professor Crookes, by obtaining a vastly better vacuum, obtained in these tubes some new and very interesting phenomena. As the vacuum became better and better, the light within the tubes finally disappeared, and only the inside of the glass was illuminated. This Professor Crookes explained upon the supposition that the air particles remaining in the tubes are repelled from the negative terminal or "cathode" within the tube, and shoot off from it, proceeding in straight lines, until they come into collision with other particles or with the walls of the tubes, producing light wherever the collision occurs. When the exhaustion is sufficient these particles shooting out from the cathode meet with no obstructions until they reach the walls of the tube, which are bombarded by the flying particles until they shine with a sort of phosphorescent light, while the whole interior of the tube remains dark.

These experiments have been repeated again and again for the last eighteen years in scientific laboratories and lecture-rooms, always exciting the greatest interest in the wonderful phenomena disclosed. But not until recently has it been known or suspected that all the time there were proceeding from the bombarded surface other rays, incapable of exciting vision, but possessing properties, and capable of producing effects even more wonderful than any that the Crookes tube had before shown. That certain invisible rays existed in the Crookes tube radiations was known about four years ago, but it remained for Professor Röntgen to demonstrate the remarkable properties which they possess. He found that a piece of card-board painted on one side with barium platino cyanide was illuminated when held near the excited Crookes tube, and that the painted surface was equally well illuminated, whether it or the reverse side of the card-board was presented to the tube. He further found that when the whole tube was

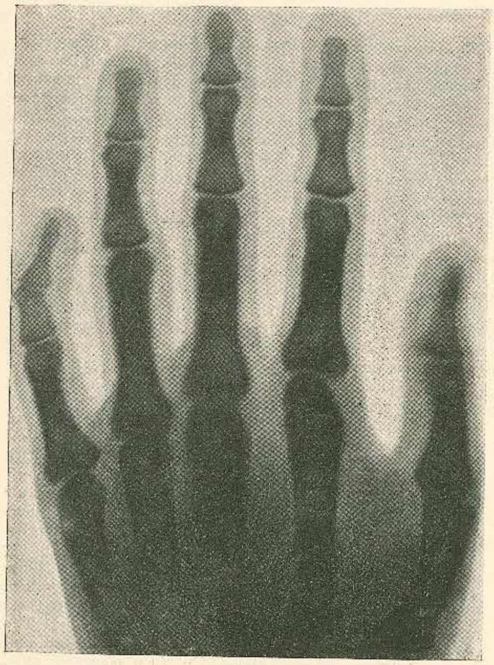


FIG. 2.—A RADIOGRAPH OF A MAN'S HAND.

covered with black paper, so that no rays affecting the eye could emerge, the painted screen was still illuminated, and further yet, that the illumination remained visible when a board an inch thick, a book of a thousand pages, or a plate of hard rubber was interposed between the tube and screen.

On the contrary, he found that glass, thin pieces of metal, the bones of the hand, more or less stopped the rays, and so cast shadows. It must have been a startling image that met Professor Röntgen's eye when first he placed his hand in the path of the rays, and saw upon the screen a bony skeleton hand with only a faint outline of flesh and cartilage. It was a startling experiment to me, after I had read all the accounts of Professor Röntgen's work, and knew what to expect, when I first saw the shadow of my own hand upon the fluorescent screen. Fig. 2 shows the appearance of such a shadow. After demonstrating in this way the transmission powers of various substances, Professor Röntgen tried the effect of the rays upon the photographic plate, and found it possible to fix there the images that he had seen upon the fluorescent screen.

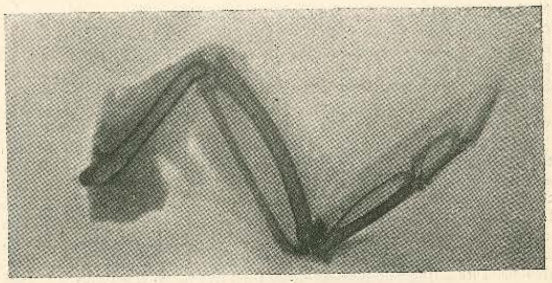


FIG. 4.—WING OF A PIGEON, SHOWING THE SHADING EFFECT IN BONES.

Fig. 1 will show how the results are obtained. A is a galvanic battery, B is a Ruhmkorff induction coil, C is a Crookes tube, and D is the plate-holder containing the sensitive plate.

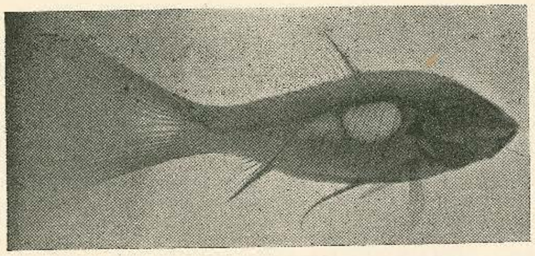


FIG. 3.—A GOLDFISH WITH THE SPINE AND SOME OF THE INTERNAL ORGANS VISIBLE.

The battery produces a low-tension harmless current that is rapidly closed and broken at the induction coil, which transforms it into a high-tension current capable of producing electric sparks, and giving exceedingly painful if not fatal electric shocks. Wires convey this high-tension current from the coil to the terminals of the Crookes tube, where the Röntgen rays are produced whenever the current is turned on. In the figure the plate-holder is shown only a few inches from the tube, where the effect of the rays is strong.

Fig. 3 shows a goldfish, with all his scales and flesh on. The line of his spine is clearly visible, and many of the inner organs of his body can be clearly seen, and the skeleton comes out very clearly, because the bones are more opaque to these rays than is any other part of the body.

Fig. 4 shows the wing of a pigeon, which is interesting, because while the outline of the flesh is distinctly marked the feathers have practically disappeared. The bones are not only clear, however, but the thinner parts are lighter than the thicker. Fig. 5 shows the leg and head of the pigeon. Around the head it is just possible to make out the outline of the feathers, the flesh is clearly marked, and all the bones of the neck are visible. In like manner the leg is interesting.

The transparency of the flesh makes it possible to show the presence and location in the body of foreign substances. Bullets, needles, and bits of glass have already been located by means of Röntgen ray photographs, and afterwards removed by a surgical operation.

It is curious that the part of the eye which is transparent to the light, and through which light passes to reach and affect the optic nerve, is nearly opaque to the Röntgen rays. Vision by means of these rays would therefore be impossible, even if the optic nerve were sensitive to them.

But suppose these rays could excite vision. What should we see? Holding a purse between the eye and a Röntgen ray source, we should see the coins within it. If a person stepped in the path of the ray we should see his bony skeleton. We might see something of his internal organs; perhaps we could see his heart beat. A broken bone could be seen, and the operation of setting it could be watched. Diseased bones or enlarged joints could be examined. Tubercles in the lungs would be visible. But these things would be visible only when they came between the eye and the source of the rays, much as on a dark night objects might be visible between you and a camp fire.

In daylight objects become visible by means of the light which falls upon them and is reflected to the eye. This brings out the detail of the visible surface. But the Röntgen rays are scarcely at all reflected, and even if they produced vision, objects would become visible only as they intercepted the rays. They would not be illuminated as they are illuminated by rays of light, and only outlines, therefore, would be seen. Even fluorescent bodies which appear light under the action of the Röntgen rays are not really illuminated, but are rendered luminous—that is, are made to shine by their own light. When bodies opaque to the rays are placed before the fluorescent screen, merely a shadow is seen on it. So the photographs or "radiographs" obtained are only shadows, but they are not the flat featureless shadows of the "shadow pictures" often introduced as an entertainment at social gatherings, when the identity of the person casting the shadow is often impossible to make out. Few substances are en-

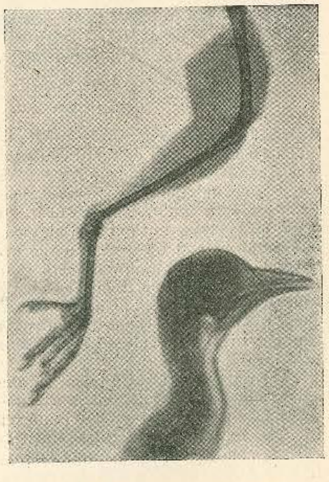


FIG. 5.—HEAD AND LEG OF PIGEON.

tirely opaque to the Röntgen rays, hence the shadows of thicker portions of an object will be deeper than of the thinner portions, and the shadow becomes a shaded picture that may give details of the surfaces of the object. A Röntgen ray shadow of an aluminum medal may show the design stamped upon the surface. The shading effect is well shown in the bones of the pigeon.

But if there are few substances entirely opaque to the newly discovered rays, there appear to be none that are entirely transparent. Even in air the rays appear to be rapidly absorbed, so that an extremely powerful apparatus is required for producing effects at any distance. Air seems to behave toward the Röntgen rays much as fog behaves to light, and it seems unlikely that effects can be procured at any great distance, perhaps not more than one hundred feet from the source.

It would be rash to attempt to predict the future of the Röntgen ray. The uses to which it may be applied in surgery have already been hinted at in this article. The transparency of wood makes it possible to inspect the work of a carpenter, and determine whether the work hidden under the exterior finish has been honestly done. Hidden compartments in a desk or cabinet might be revealed. The contents of a packing-box might be ascertained without opening it. But to scientific men these rays have a very great interest. What are they? Are they vibrating movements transmitted in waves, like light? Are they particles shot off from the Crookes tube and flying with enormous velocity? These are questions to be answered.

When you stand in front of a Crookes tube in action these flying particles are streaming through your body, stopping not at all at your clothing, and hardly at all checked by the flesh, nor wholly stopped even by the bones. A hard-wood board held between you and the tube is no protection. The streams pass through it unchecked. Sheets of metal even do not wholly stop them. The wonder of it all is that for nearly twenty years experimenters with the Crookes tube have been pierced through and through by these subtle streams and have never known it. Do they produce any effect as they pass through the body? Can they cause or cure disease?

It has been proved that they pass quite freely through the lungs, but if tubercules are present they stop the rays. Might not the touch of the flowing streams dissipate the tuberculosis growth and restore health? Questions like these are coming up for solution, and experimenters are seeking the answers. The study of the Röntgen ray has just begun. What may not the next few months bring forth!

AN "OLD-FIELD" SCHOOL-GIRL.*

BY MARION HARLAND.

CHAPTER IV.

THE Foggs lived on a funny little piece of land wedged in between two of the Greenfield farms. The house was a cabin of two rooms, with a stone chimney built on the outside, but the Foggs boasted that fifty-three children had been born and brought up in it. How they lived was a partial mystery to the neighborhood. They raised corn and potatoes and little else in the ground enclosed by a "worm-fence," built, it was more than suspected, of rails stolen, a few at a time, from the Greenfield fences. An acre of woodland behind the house was supposed to furnish them with fuel, and there were always pigs and chickens running wild, with a dozen or so children, in the road and fields.

They were "poor white folks" in a county where nearly everybody was respectable and well-to-do. No member of the family was ever convicted of an offence that took him into the courts. They might be suspected of stealing chickens, pigs, and wood, and even of robbing a smoke-house once in a while, but nothing was ever proved against them. Not one of them, so far as was known, had ever been in prison, and not one had ever grown rich or really respectable.

As the Grigsby children, neat and trim, lunch bags and books in hand, passed the Fogg cabin on the Monday morning the school opened, two men and four children were in and about the yard. Mrs. Fogg, the mistress of the house, stood on the porch, her married daughter, with two dirty babies holding to her skirt, leaned against a corner of the chimney; a barefoot boy was chopping sticks upon a log, a smaller boy trying to grind his knife upon a grind-stone. All stopped what they were doing to stare at the sisters and brother, and the elder matron hailed them in a coarse voice more like a man's than a woman's.

"Goin' t' school, ain't you?"

Dee nodded without halting; Bea walked straight onward, her chin level, her white sun-bonnet hiding her face. To her horror and displeasure Flea stopped, and replied politely over the tumble-down fence:

"Good-morning, Mrs. Fogg! I hope you are all well to-day."

"Tolerable, thank God!" said the old woman, changing her tone into a snuffling whine. "Ain't you too soon fo' school? The teacher 'ain' gone by yet."

"We like to be in good time," rejoined Flea, affably. "Aren't your boys going?"

"No, bless you, honey. Major Duncomb won't let them go in on the county, an' pore folks ain't got no money to pay teachers with. Ah well! Th' Almighty, He knows! The new teacher's real spry, ain' he?"

"Flea Grigsby!" called Bea, over her shoulder. "Come right along, or I'll tell ma when I go home."

Flea noticed her as little as she noticed Mrs. Fogg's remark on the new teacher's spryness. She had an idea, and was in a hurry to air it. "Major Duncombe!" she repeated. "Could he let the children in free if he liked?"

"Cert'nly, honey! He has the fus' word in all the county. Nobody dar' say his soul's his own 'less he lets 'em. 'Lord! how long? how long?'"

"I am *very* well acquainted with Major Duncombe," rushed on Flea, with an important air. "And you may be sure, Mrs. Fogg, that I'll speak to him about your grandchildren. Good-morning!"

She was out of breath when she overtook her sister. Bea had walked fast purposely to make the others run, loyal Dee having loitered behind with Flea.

"I should think you'd be 'shamed of yourself, stoppin' to talk with poor white folks 'long the road," commented the elder sister.

Flea smiled mysteriously. "I had business with Mrs. Fogg."

"Business! Well, I never! The less you have to do with that kind, the better."

"Mrs. Fogg is not a bad woman, Bea," said Flea, seriously. "When you ask how she is, she always says, 'Pretty well, thank God,' just like Mrs. Elton in *Anna Ross*. I think she is a very pious person, and it is not her fault that she is poor. I stopped in the porch once when it was raining, and she talked a great deal about the trouble she had had, and how much she prayed, and so on. If I could, I'd be a benefactor to people like that."

"I think sometimes you 'ain't got the sense you were born with, Flea Grigsby. The idea o' you *benefacting* anything or anybody!"

Flea's smile was yet more mysterious. In her glee over her new scheme she squeezed Dee's arm.

"You wait and see! *We* know—don't we, Dee?"

"Yes, *sir-r-r!*" said Dee, stoutly.

The prospective benefactress was still swelling with her secret when they arrived at the school-house. The boys sat on one side of the room, the girls on the other, a narrow aisle separating them. Dee dropped into a seat near the door; the girls walked well forward and took places close to the aisle. Three minutes afterward the teacher appeared in the doorway, and Major Duncombe with him. Whispers and shuffling ceased instantly; all eyes were fixed upon the two gentlemen as they went up to the top of the room, turning there to face the school. It was all quite proper and dignified, until the Major, having motioned

* Begun in HARPER'S ROUND TABLE No. 857.

New York, March 25th, 1896.
#46 & 48 E. Houston Str.

Prof. Wm. A. Anthony,
#5 Beekman Str.,
N. Y. City.
My dear Prof. Anthony: -

Your letter of March 24th has been duly received. I am glad were pleased with the pictures. I should have stated that the distances were from 20 to 24 inches with exposures of from 5 to 15 minutes.

In regard to reflection by tube, glass or copper, as I told you the other day while I performed the experiment, the test did not seem to me anything like as conclusive as the experiment I published in the Electrical Review, number before last. I now see that you are right, and the field should be uniform at the end of the tube. The first experiment did not show that, but showed a luminous circle near the edge on one side. The increased effect inside of the tubular space might have been due, I thought, to the fact that the space outside of the tube was less acted upon. It was only later, after I conclusively demonstrated the reflection, that I hit upon the plan of using one and same plate in a number of experiments.

Since I have demonstrated the reflection it was easy to magnify the effects upon the plate and I am getting some interestin[sic] results.

I do not think that Prof. J. J. Thomson's experiment, as he published it, is conclusive. He is very likely working with inadequate apparatus and might not have been able to detect anything. I think, however, that even if he should have had an apparatus capable of producing the effect, it would still not be conclusive; but this would lead me too far.

Your suggestion as to putting the plate in a separate vacuum might lead to some interesting revelation. I will keep it in mind, and if I can find time I will try it.

Sincerely yours,

The New Non-Phosphorescent Crystals, Positively SUPERIOR TO CALCIUM TUNGSTATE
Spring Park Laboratory,
Manufacturers of
Scientific and Electrical Instruments,
X-Ray Outfits
Fine Chemicals. Calcium Tungstate Crystals all Sizes.
Fluoroscopes, Fluorescent Screens, Photographic Screens, Crookes Tubes,
X-Ray Photograph plate holder for Plate or Bromide Paper.
38 SPRING PARK AVENUE,
T. B. Kinraide, Treas. and Manager.
Jamaica Plain, Feb. 24 - 1897

Mr. Nikola Tesla;

Dear Sir,

We send you a small sample screen made from our Non Phosphorescent Crystals which think is a great improvement in the Calcium Tungstate so much in use. We will send you a Fluoroscope (gratis) made from the same material if you will kindly let us know what size you prefer, as we should like you to give our Fluoroscopes a thorough trial.

We do this without in any way soliciting you to give us a testimonial regarding them: other than that you would naturally make regarding anything you found superior for any special use. If you find our screens are better than most others in the market, naturally you would so refer to them and more we do not ask or expect.

Trusting you will let us send you one our Fluoroscopes, We are, Very truly yours,
Spring Park Laboratory, Mr. T. B. Kinraide

New York, Feb. 25th, 1897.
#46 & 48 E. Houston Str.

Mr. T. B. Kinraid,
38 Spring Park Ave.,
Jamaica Plain, Mass.

My Dear Sir: -

Your letter of Feb. 24th has been received.

I am naturally interested in every advance and am ready to acknowledge the merit of those, whom, in my honest opinion, it is due. But it has been my principle not to make any public statements for commercial use, even of my very best friends. If, however, you have any screens which you think are better than the old ones, kindly send me one and let me pay for it as every other of your customers does. Only on such condition could I possibly accept one.

I shall be much obliged for any attention you will devote to the matter.
Yours very truly,

The New Non-Phosphorescent Crystals, Positively SUPERIOR TO CALCIUM TUNGSTATE
Spring Park Laboratory,
Manufacturers of
Scientific and Electrical Instruments,
X-Ray Outfits
Fine Chemicals. Calcium Tungstate Crystals all Sizes.
Fluoroscopes, Fluorescent Screens, Photographic Screens, Crookes Tubes,
X-Ray Photograph plate holder for Plate or Bromide Paper.
38 SPRING PARK AVENUE,
T. B. Kinraide, Treas. and Manager.
Jamaica Plain, March 15 - 1897

Mr. Nikola Tesla
46 Houston St.

Boston Mass.

Dear Sir:

We forward you today one of our Non Phosphorescent Fluoroscopes which we think upon trial you will find much superior to the Calcium Tungstate Crystals in general use as there is no phosphorescence to obscure or dim the images and the definition of the object is so much more clear and sharp.

We appreciate your attitude when you say that you never make any public statements for commercial use even for your best friends. We did not expect or ask you to anything of the kind and fear we but poorly express ourselves if our communication was open to that interpretation.

However, we send you the fluoroscope which you can submit to test and comparison with any others. We should be glad to give you as a token of our appreciation of the original work you have done: but if you insist on paying for it only do so after you find it is something you want.

Very truly yours,
Spring Park Laboratory
Mr. T. B. Kinraide
K

New York, March 21rst, 1897
#46 & 48 E. Houston Str.

Spring Park Laboratory,
#38 Park Avenue,
Jamaica Plain, Mass.

Gentlemen: -

Your favor of March 15th has been received. Your Roentgen screen has also reached me and I have found it satisfactory. I do not like to comment upon its merits in comparison with others and only wish to say that I will retain it. Kindly mail me the bill at your earliest convenience.

In examining the screen I have noted that you have utilized some suggestions. I am not saying this in any critical spirit, on the contrary, I am glad you have done so and you are welcome to any advantage which may result to you therefrom.

Should you have any new phosphorescent material I wish you will send me some for trial.

Believe me to be,
Yours very truly,

New York, June 6th, 1897.
#46 & 48 E. Houston Str.

Spring Park Laboratory,
Jamaica Plain, Mass.

Gentlemen: -

I have up to this moment received no bill for the fluoroscope forwarded to me some time ago. As I cannot possibly retain it unless you allow me to pay for it as any other customer would, I would beg you to forward me the bill with the least possible delay.

I have been satisfied with its performance and, although there are at present better screens in the market, I am using it still.

Yours very truly,

The New Non-Phosphorescent Crystals, Positively SUPERIOR TO CALCIUM TUNGSTATE
Spring Park Laboratory,
Manufacturers of
Scientific and Electrical Instruments,
X-Ray Outfits
Fine Chemicals. Calcium Tungstate Crystals all Sizes.
Fluoroscopes, Fluorescent Screens, Photographic Screens, Crookes Tubes,
X-Ray Photograph plate holder for Plate or Bromide Paper.
38 SPRING PARK AVENUE,
T. B. Kinraide, Treas. and Manager.
Jamaica Plain, June 7 - 1897

Mr. N. Tesla
46 Houston St.
New York, N.Y.

Dear Sir

Enclosed find bill for the fluoroscope as per your request. We are getting out a new fluoroscope, with detachable screen of a new and improved salt, mounted in Mahogany, and we are waiting to have them finished intending to send you one and allow you to choose which you would prefer to keep before bill you. However, the exchange can be made at any time?

Very truly yours,
Spring Park Laboratory
K

New York, Nov. 6th, 1897.
#46 & 48 E. Houston Str.

TO WHOM IT MAY CONCERN:

This is to certify that Mr. B. Hiergesell has been in my employ for six years. I have found him to be an honest and diligent workman.

New York, Sep. 26th, 1898.
#46 & 48 E. Houston Str.

Mr. E. L. Ovington,
29 Cortlandt Str.,
New York City.
Dear Sir: -

I have already delivered three lectures on high potential high frequency currents, as this the number of all good things.

As I do not know anything of post mortem arrangements, I cannot supply the necessary information.

Yours very truly,

4 Newcastle Court,
Boston, Mass.

Mr. Nikola Tesla,
New York City.

Dear Sir: -

The writer would appreciate a copy of your circular, the front page of which is reproduced in fac-simile in the Electrical World and Engineer of February 6, 1904.

The writer remembers with pleasure meeting you in your old laboratory at 46 East Houstan[sic] Street some few years ago.

Yours truly,

Earle L. Ovington

Dictated.

The Annual Dinner of the American Institute of Electrical Engineers.

The annual dinner of the American Institute of Electrical Engineers will be held in the main ball room of the Waldorf-Astoria, New York City, Thursday, February 11, 1904, at 7 P.M., precisely. The guest of honor will be Mr. Thomas Alva Edison, and it is expected that an opportunity will be given to meet Mr. Edison at an informal reception, at half-past 6. This dinner will commemorate the twenty-fifth anniversary of the introduction of the incandescent lamp, and will also celebrate Mr. Edison's birthday. Upon this occasion will also be presented the deed of gift of the Edison Medal Association, which has raised a fund of several thousand dollars.

The following guests have accepted invitations: Mr. Ambrose Swasey, president American Society of Mechanical Engineers; Dr. A. R. Ledoux, president American Institute of Mining Engineers; Col. Robert Clowry, president Western Union Telegraph Company; Mr. George G. Ward, vice-president and manager Commercial Cable Company; Mr. W. H. Baker, vice-president Postal Telegraph Cable Company; Mr. John Fritz, founder Bethlehem Steel & Iron Works; Mr. W. H. Fletcher, president Engineers' Club; Mr. A. B. Chandler, president Postal Telegraph-Cable Company.

Autographed souvenir menus have been prepared containing a colored photogravure of Mr. Edison and two original poems prepared by Mr. R. R. Bowker. The exercises will be as follows: Salutatory address by President B. J. Arnold; presentation of the medal fund and deed of gift by Mr. Samuel Insull, chairman of the Edison Medal Association; acceptance of same on behalf of the Institute by Dr. A. E. Kennelly, of Harvard University, past president; address on behalf of the colleges and universities by Prof. Cyrus F. Brackett, of Princeton University; address on behalf of the Association of Edison Illuminating Companies by President J. B. McCall; address on behalf of the National Electric Light Association by President Charles L. Edgar.

Mr. Edison has flatly declined to speak, but in response to the toast in his honor has agreed to send from the table a telegraphic acknowledgment. It is a great many years since he used the key. He will use one of the original quad sets built by him for, and loaned by the Western Union Telegraph Company. The message will be received in the banquet hall on a Postal quad of latest date by President A. B. Chandler, of the Postal Telegraph Cable Company, and will then be read to the audience. These arrangements are in the hands of Mr. C. P. Bruch, assistant general manager of the Postal system, and Mr. J. C. Barclay, chief engineer of the Western Union system. A number of special cable messages and telegrams will also be received at the same time.

The seating arrangements provide for the accommodation of eight persons at each table. Orders for seats should be sent in at once and should be accompanied by cash or check, payable to Mr. Ralph W. Pope, secretary. Price of tickets, without wine: Gentlemen, $7; ladies, $5; admission to galleries, $1. In order to secure accommodation, responses should reach Mr. Pope not later than February 9, 1904, 95 Liberty Street, New York. Mr. Arthur Williams, chairman of the committee on decorations, has made elaborate preparations for ornamenting and illuminating the ball room, and the effect will be very pretty and appropriate.

A Striking Tesla Manifesto.

We reproduce herewith in slightly reduced fac-simile the first page of a four-page circular which has been issued this week by Mr. Nikola Tesla in a large square envelope bearing a large red wax seal with the initials, "N. T." At the back of the page which we reproduce is given a list of 93 patents issued in this country to Mr. Tesla. The fourth page is blank. The third page has a little vignette of Niagara Falls and is devoted to quotations from various utterances of Mr. Tesla. The first of these is from his lecture delivered in 1893 before the Franklin Institute and the National Electric Light Association, as to transmission of intelligible signals and power to any distance without the use of wires. The second quotation is from his article on the problem of increasing human energy, which appeared in the *Century Magazine* in June, 1900, dealing with virtually the same subject. The third item quotes from his patents, Nos. 645,576 and 649,621, dealing with the transmission of electrical energy in any quantity to any distance, with transmitting and receiving apparatus movable as in ships or balloons. The circular is an extremely interesting one. It is most sumptuously got up on vellum paper and altogether constitutes a manifesto worthy of the original genius issuing it. It is to be gathered from the circular that Mr. Tesla proposes to enter the field of consulting engineership, in which he already has enjoyed an extensive connection here and abroad.



New York, January 1, 1904

I wish to announce that in connection with the commercial introduction of my inventions I shall render professional services in the general capacity of consulting electrician and engineer.

The near future, I expect with confidence, will be a witness of revolutionary departures in the production, transformation and transmission of energy, transportation, lighting, manufacture of chemical compounds, telegraphy, telephony and other arts and industries.

In my opinion, these advances are certain to follow from the universal adoption of high-potential and high-frequency currents and novel regenerative processes of refrigeration to very low temperatures.

Much of the old apparatus will have to be improved, and much of the new developed, and I believe that while furthering my own inventions, I shall be more helpful in this evolution by placing at the disposal of others the knowledge and experience I have gained.

Special attention will be given by me to the solution of problems requiring both expert information and inventive resource—work coming within the sphere of my constant training and predilection.

I shall undertake the experimental investigation and perfection of ideas, methods and appliances, the devising of useful expedients and, in particular, the design and construction of machinery for the attainment of desired results.

Any task submitted to and accepted by me, will be carried out thoroughly and conscientiously.

Laboratory, Long Island, N. Y.
Residence, Waldorf, New York City.

Nikola Tesla

PAGE FROM CIRCULAR SHOWING TESLA TOWER, WARDENCLIFFE, LONG ISLAND.

NIHIL IN SACCULO QUOD NON FUERIT IN CAPITE

Electrical oscillator activity ten million Horsepower



Power transmission without wires

New York, January 1, 1904

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Any task submitted to and accepted by me, will be carried out thoroughly and conscientiously.

Laboratory, Long Island, N. Y.
Residence, Waldorf, New York City.

Nikola Tesla

Burning atmospheric nitrogen by high frequency discharge twelve million volts



"In connection with resonance effects and the * * * transmission of energy over a single conductor, * * * I would say a few words on a subject which constantly fills my thoughts, and which concerns the welfare of all. I mean the transmission of intelligible signals or, perhaps, even power, to any distance without the use of wires. I am becoming daily more convinced of the practicability of the scheme; and though I know full well that the great majority of scientific men will not believe that such results can be practically and immediately realized, yet I think that all consider the developments in recent years by a number of workers to have been such as to encourage thought and experiment in this direction. My conviction has grown so strong that I no longer look upon this plan of energy or intelligence transmission as a mere theoretical possibility, but as a serious problem in electrical engineering, which must be carried out some day. * * * In fact, what is there against the carrying out of such a scheme? We now know that electric vibration may be transmitted through a single conductor. Why, then, not try to avail ourselves of the earth for this purpose? * * * Theoretically, it could not require a great amount of energy to produce a disturbance perceptible at great distance, or even all over the surface of the globe. I think that, beyond doubt, it is possible to operate electrical devices in a city, through the ground or pipe system, by resonance from an electrical oscillator located at a central point. But the practical solution of this problem would be of incomparably smaller benefit to man than the realization of the scheme of transmitting intelligence or, perhaps, power, to any distance through the earth or environing medium. Proper apparatus must first be produced, by means of which the problem can be attacked, and I have devoted much thought to this subject. I am firmly convinced that it can be done, and hope that we shall live to see it done."—*Light and Other High-frequency Phenomena.**

*Lecture delivered before the Franklin Institute, Philadelphia, February, 1893, and before the National Electric Light Association, St. Louis, March, 1893.

"Electrical effects of any desired character and of intensities undreamed of before are now easily producible by perfected apparatus of this kind * * *. I have produced electrical discharges, the actual path of which, from end to end, was probably more than one hundred feet long; but it would not be difficult to reach lengths one hundred times as great. I have produced electrical movements occurring at the rate of approximately one hundred thousand horse-power, but rates of one, five, or ten million horse-power are easily practicable. In these experiments effects were developed incomparably greater than any ever produced by human agencies, and yet these results are but an embryo of what is to be. That communication without wires to any point of the globe is practicable with such apparatus would need no demonstration, but through a discovery I made I obtained absolute certitude. Popularly explained, it is exactly this: When we raise the voice and hear an echo in reply, we know that the sound of the voice must have reached a distant wall, or boundary, and must have been reflected from the same. Exactly as the sound, so an electrical wave is reflected, and the same evidence which is afforded by an echo is offered by an electrical phenomenon known as a 'stationary' wave—that is, a wave with fixed nodal and ventral regions. Instead of sending sound vibrations toward a distant wall, I have sent electrical vibrations toward the remote boundaries of the earth, and instead of the wall, the earth has replied. In place of an echo I have obtained a stationary electrical wave * * *."—*The Problem of Increasing Human Energy, Century, June, 1900.*

"By the discovery of these facts and perfection of means * * * it becomes possible to transmit * * * electrical energy * * * for industrial uses on a large scale up to practically any amount and, according to all the experimental evidence I have obtained, to any terrestrial distance. * * * The transmitting as well as receiving apparatus may be * * * movable as, when * * * carried by vessels floating in the air or by ships at sea * * *."—*U. S. Patents Nos. 645,576 and 649,621.*



UNITED STATES PATENTS GRANTED TO NIKOLA TESLA

334,823	390,820	447,920	514,972	609,250
335,786	396,121	454,622	514,973	609,251
335,787	401,520	455,067	517,900	611,719
336,961	405,858	455,068	524,426	613,735
336,962	405,859	455,069	555,190	613,809
350,704	406,968	459,772	568,176	645,576
359,748	416,192	462,418	568,177	649,621
381,968	416,193	464,666	568,178	11,865
381,969	416,194	464,667	568,179	685,012
381,970	416,195	487,796	568,180	685,953
382,279	417,794	511,559	577,670	685,954
382,280	418,248	511,560	577,671	685,955
382,281	424,036	511,915	583,953	685,956
382,282	433,700	511,916	593,138	685,957
382,845	433,701	512,340	609,245	685,958
390,413	433,702	514,167	609,246	723,188
390,414	433,703	514,168	609,247	725,605
390,415	445,207	514,169	609,248	
390,721	447,921	514,170	609,249	



Excerpts from Leland Anderson Collection on Nikola Tesla
Detre Library and Archives, Senator John Heinz History Center

OVINGTON MANUFACTURING COMPANY
METROPOLITAN BUILDING, 1 MADISON AVENUE
NEW YORK CITY

Ovington
ELECTRO-THERAPEUTIC
APPARATUS

TELEPHONE CONNECTION

April 12th, 1906.

Mr. Nikola Tesla, Waldorf Astoria,

New York.

WHOLE TESLE

Dear Sir:-

The writer has learned that you contemplate putting on the market, shortly high frequency apparatus for X-Ray and therapeutic purposes. We make a specialty of High Frequency machines, and write to ask whether you would be open to a proposition whereby our Company should undertake the selling, or perhaps the selling and manufacture, of your machine. The writer had the pleasure of meeting you some years ago at your laboratory, #46 East Houston Street, and he should like to have the pleasure of renewing the acquaintance. If you are in the neighborhood of the Metropolitan Building, I should be glad to see you at any time, or if you will make an appointment with me, I shall be pleased to call upon you.

Yours very truly,
OVINGTON MANUFACTURING COMPANY.

ELO-N.
Earle L. Ovington, President

Copy.

T E S L A L A B OR A T O R Y,
Wardenclyffe, Long Island, N. Y.

April 23, 1906.

Ovington Manufacturing Co.,
1 Madison Ave., New York City, N. Y.

Gentlemen: -

Your letter of April 12th addressed to Mr. Nikola Tesla was duly received, but he was unable to reply as he had been afflicted with a bad cold since sometime.

He instructs me to write you that he would be very interested to receive a definite propositions from you. Will you not be kind enough to send him also copies of your catalogue illustrating the articles you manufacture and copies of your patent specifications covering the same, to his above address.

Yours very truly,

130 W 84 St
New York
Mar 25, 1910.

Mr. Nikola Tesla,
Waldorf Astoria,
N. Y.

Dear Sir: -

I am going to Boston where I am equipping a small laboratory to carry on some research work. As I leave in a few days I write to ask if you will make an appointment with me to discuss a certain matter before I go. I have phoned several times but you have been out.

You may perhaps have heard of my lectures on high frequency at various electric shows.

Looking forward to meeting you with great pleasure, I am,

Very truly yours,
Earle L. Ovington

165 Broadway, New York,
March 26th, 1910.

Earle L. Ovington, Esq.,
130 W. 84th St.,
New York, N. Y.

Dear Sir:

Replying to your favor of March 25th just received, I wish to say that I will be glad to see you at your convenience, if you will call at this office. Your telephone messages have been transmitted to me but I was unable to call you up for want of time.

Yours very truly,

FREDERICK F. STRONG, M. D.,
ELECTRO-THERAPEUTICS,
AND PATHOLOGICAL EXAMINATIONS.
BOSTON, MASS.

176 Huntington Ave. Sept 27.1898.

Mr Nikola Tesla, -
New York City.

My Dear Sir,-

I trust you will pardon the liberty I take in writing to you, but I am very anxious to have your opinion in regard to certain matters. For the past three years I have been engaged in a clinical study of the Tesla High-frequency currents in their application to the treatment of disease. Apostoli and D'Arsonval have done some work in this line with very remarkable results, especially in rheumatic conditions. Their current was derived from a Tesla coil excited by the discharge of a static machine with suitable condensers. They employed a current capable of giving a spark of from 1 to 2 cm in air. My researches have differed, in that I have employed an apparatus of my own design, consisting of a large transformer, condenser in oil, and Tesla coil, the spark gap being a revolving metal plate studded with wings which move past a stationary ball. I employ a 104 v alt incandescent current, and obtain a spark about 6 in long from my Tesla coil.

I have recently seen a machine of a novel character, and have made one like it. It is the best “X-Ray machine” I ever say, and I am anxious to know whether it would have a similar therapeutic effect to the machine that I have been using. A patent has been applied for on the apparatus, and I should be glad to have your opinion as to whether there is anything patentable about it. It consists of a small spark coil wound with a pound or two of No 20 wire: this is in two sections: the extreme ends of the sections are connected directly to the 110 v direct incandescent current, while the two inner ends of the sections are attached to an Interrupting device consisting of an eccentric iron disc which is made to revolve by the magnetism of the core of the coil. This disc bears two studs which come in contact with a short bar, which, when at rest, is held in contact with a post provided with a platinum terminal. This contact is broken every time a stud hits the end of the bar. The coil ends are connected, one to the spring bar, and one to the post. The current is broken in such a manner that the iron disc revolves rapidly on the principal of a simple motor. A mica condenser is connected around the break to absorb the current generated by the self-induction of the coil. This condenser is provided with a discharging circuit consisting of a Tesla primary formed by 5 layers of copper foil 1 inch in width: the coil being 1 foot in diameter. A spark gap is included in the circuit consisting of two copper plates a short distance apart.

The Tesla secondary consists of a disc 1 foot in diam, and a quarter of an inch thick, and is formed of a pound of no.36 wound and embedded in paraffin. The spark coil draws half an ampere and the Tesla coil gives sparks six inches long. To me the idea was entirely new, and I should be glad to know if it is patentable. The current in the Tesla coil is uni-directional, and the sparks are synchronous with the breaks of the spark coil circuit. The current is harmless: one can draw six inch sparks from the positive pole without injury, while scarcely any spark can be drawn from the negative terminal. The makers claim that it gives an oscillating high-frequency current, but it

seems to me that the frequency is the same as the number of breaks in the spark coil circuit. Passing the hand in front of a Crookes tube excited by the machine gives a succession of images, as is the case with an ordinary Rhumkorff, and this suggests to me that the frequency is low. Will you kindly give me your opinion on the following points.

What has been your experience in regard to the curative power of high-frequency currents?

What are the requirements of such a current, in order to be of value medically?

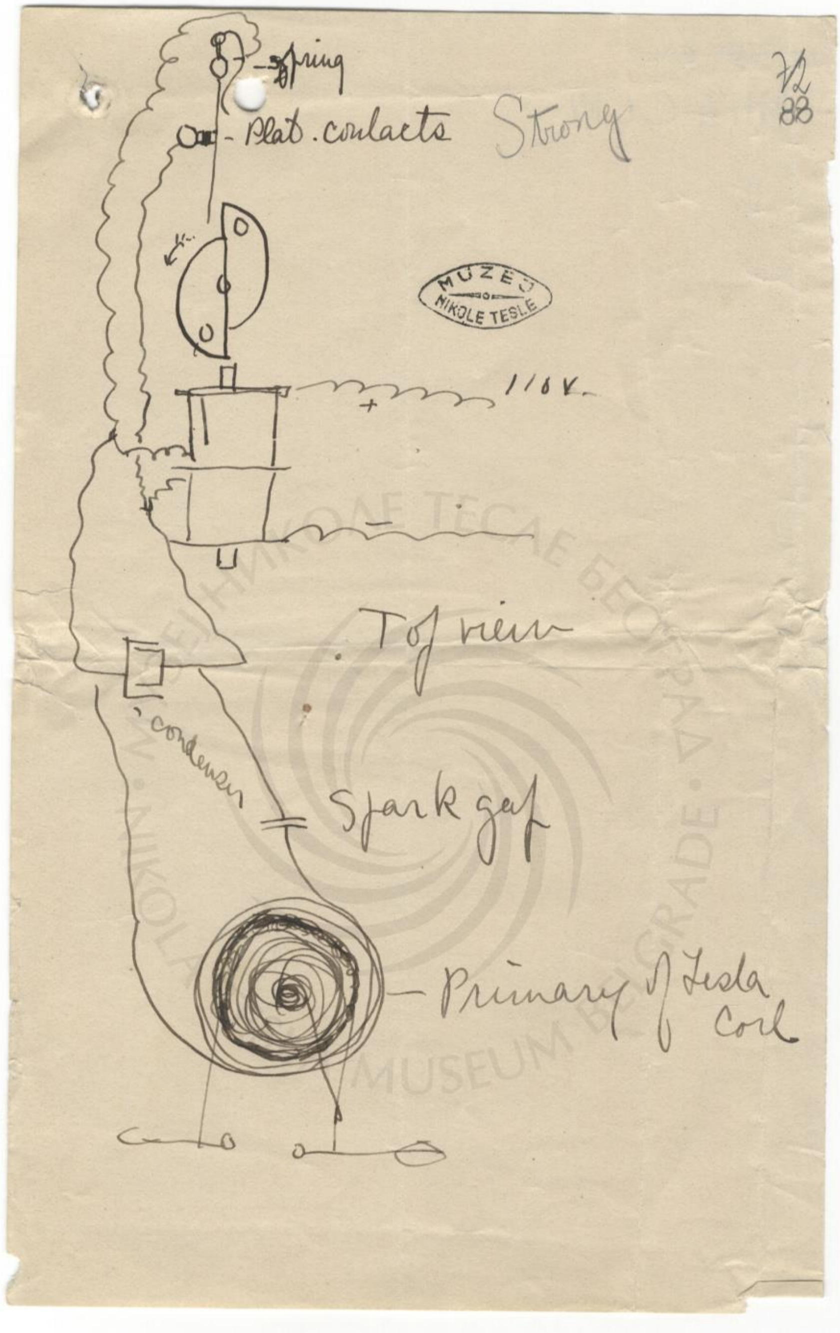
Would the above-described machine give therapeutic results similar to those given by an alternating machine, such as the one I have described as having use for medical purposes?

If the apparatus just described a true high-frequency coll, or am I right in supposing the frequency to be low? (the voltage of the current used to charge the condenser is only 3000)

If you can find time to answer these questions you will confer a great favor upon me, and aid me greatly in my researches. I trust I may have the honor of meeting you personally at some future time. Trusting that you will pardon me for my freedom in asking for Information and trusting that I may hear from you soon, I remain

Very respectfully,
Frederick F. Strong

#176 Huntington Ave Boston



MNT, CLIII,
K 153

88 A

New York, Oct. 4th, 1898.
#46 & 48 E. Houston Str.

Mr. Frederick F. Strong, M. D.,
176 Huntington Ave.,
Boston, Mass.

Dear Sir: -

Your favor of Sep. 27th has been duly received and contents noted.

I do not see any patentable feature in the arrangement shown in your sketch. There is a self-induction coil provided to charge a condenser, and the later discharges through the primary of an induction coil, a scheme which is now well known. As to the mechanical details of the break, they are likewise not novel.

The coil would be very much improved by doing away with the spark gap, in which there is necessarily a certain amount of energy consumed.

I cannot give you any idea of frequency, as I do not know the capacity of the condenser and the self-induction of the primary coil, through which it discharges. It might be from, say, twenty to two or three hundred thousand per second. What you see there when moving the hand in the light of a vacuum tube, are the fundamental interruptions of the break, but each of these may again consist of a great number of superimposed and quick vibrations. It is evident, however, that since there is a spark gap in the path of the condenser current, these vibrations die out very quickly and their effect is very small.

Although I have experimented a great deal with high frequency currents, I could tell you little as to their effect upon the body from the standpoint of a physician. In a paper which I have forwarded to the recent meeting of the Electro-Therapeutic Society I have dwelt on the subject, and you might find in what I have said one or two items of interest.

The currents obtained from the machine you to are very sudden, and I should say that they would be less suitable for certain electro-therapeutic uses than a machine giving sinusoidal currents; at least, it is generally believed the latter currents are preferred for medical purposes. I do not know exactly how that idea originated, but I think it is very likely that it followed from the observation early made, that a greater number of energy can be passed through the body of a patient when the currents are harmonically varying than when they are sudden.

In connection with the subject it may interest you to know that I am just bringing out instruments of a greatly improved design which will, in all probability, fill a much needed want. I hope that soon you will be able to procure such an instrument, if you so desire, and I have no doubt that you will be satisfied with its performance.

Yours very truly,

The Electrical Engineer.

Vol. XXVI. NOVEMBER 17, 1898. No. 550.

MISCELLANEOUS

High Frequency Oscillators for Electro-therapeutic and Other Purposes.[1]

BY NIKOLA TESLA.

SOME theoretical possibilities offered by currents of very high frequency and observations which I casually made while pursuing experiments with alternating currents, as well as the stimulating influence of the work of Hertz and of views boldly put forth by Oliver Lodge, determined me some time during 1889 to enter a systematic investigation of high frequency phenomena, and the results soon reached were such as to justify further efforts towards providing the laboratory with efficient means for carrying on the research in this particular field, which has proved itself so fruitful since. As a consequence alternators of special design were constructed and various arrangements for converting ordinary into high frequency currents perfected, both of which were duly described and are now —I assume—familiar.

One of the early observed and remarkable features of the high frequency currents, and one which was chiefly of interest to the physician, was their apparent harmlessness which made it possible to pass relatively great amounts of electrical energy through the body of a person without causing pain or serious discomfort. This peculiarity which, together with other mostly unlooked-for properties of these currents I had the honor to bring to the attention of scientific men first in an article in a technical journal in February, 1891, and in subsequent contributions to scientific societies, made it at once evident, that these currents would lend themselves particularly to electro-therapeutic uses.

With regard to the electrical actions in general, and by analogy, it was reasonable to infer that the physiological effects, however complex, might be resolved in three classes. First the statical, that is, such as are chiefly dependent on the magnitude of electrical potential; second, the dynamical, that is, those principally dependent on the quality of electrical movement or current's strength through the body, and third, effects of a distinct nature due to electrical waves or oscillations, that is, impulses in which the electrical energy is alternately passing in more or less rapid succession through the static and dynamic forms.

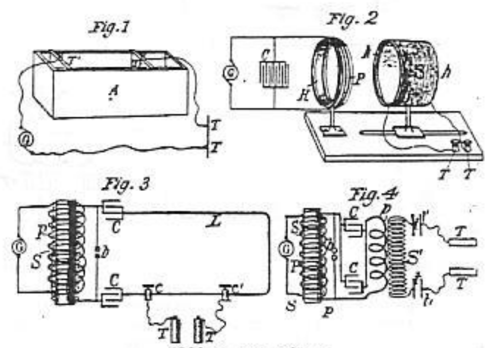
Most generally in practice these different actions are co-existent, but by a suitable selection of apparatus and observance of conditions the experimenter may make one or other of these effects predominate. Thus he may pass through the body, or any part of the same, currents of comparatively large volume under a small electrical pressure, or he may subject the body to a high electrical pressure while the current is negligibly small, or he may put the patient under the influence of electrical waves transmitted, if desired, at considerable distance through space.

While it remained for the physician to investigate the specific actions on the organism and indicate proper methods of treatment, the various ways of applying these currents to the body of a patient suggested themselves readily to the electrician.

As one cannot be too clear in describing a subject, a diagrammatic illustration of the several modes of connecting the circuits which I will enumerate, though obvious for the majority, is deemed of advantage.

The first and simplest method of applying the currents was to connect the body of the patient to two points of the generator, be it a dynamo or induction coil. Fig. 1 is intended to illustrate this case. The alternator G may be one giving from five to ten thousand complete vibrations per second, this number being still within the limit of practicability. The electromotive force—as measured by a hot wire instrument—may be from fifty to one hundred volts. To enable strong currents to be passed through the tissues, the terminals T T, which serve to establish contact with the patient's body should, of course, be of large area, and covered with cloth saturated with a solution of electrolyte harmless to the skin, or else the contacts are made by immersion. The regulation of the currents is best effected by means of an insulating trough A provided with two metal terminals T' T' of considerable surface, one of which, at least, should be movable. The trough is filled with water, and an electrolytic solution is added to the same, until a degree of conductivity is obtained suitable for the experiments.

When it is desired to use small currents of high tension, a secondary coil is resorted to, as illustrated in Fig. 2. I have found it from the outset convenient to make a departure from the ordinary ways of winding the coils with a considerable number of small turns. For many reasons the physician will find it better to provide a large hoop H of not less than, say, three feet in diameter and preferably more, and to wind upon it a few turns of stout cable P. The secondary coil S is easily prepared by taking two wooden hoops h h and joining them with stiff cardboard. One single layer of ordinary magnet wire, and not too thin at that, will be generally sufficient, the number of turns necessary for the particular use for which the coil is intended being easily ascertained by a few trials. Two plates of large surface, forming an adjustable condenser, may be used for the purpose of synchronizing the secondary with the primary circuit, but this is generally not necessary. In this manner a



FIGS. 1, 2, 3 AND 4.

cheap coil is obtained, and one which cannot be easily injured. Additional advantages, however, will be found in the perfect regulation which is effected merely by altering the distance between the primary and secondary, for which adjustment provision should be made, and, furthermore, in the occurrence of harmonics which are more pronounced in such large coils of thick wire, situated at some distance from the primary.

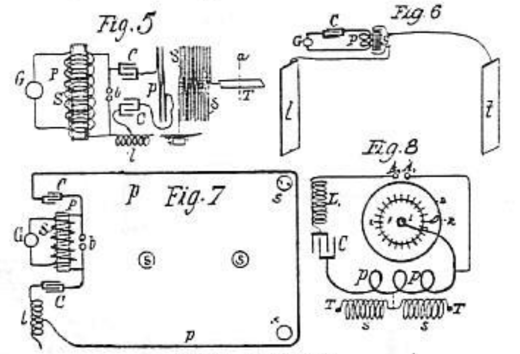
The preceding arrangements may also be used with alternating or interrupted currents of low frequency, but certain peculiar properties of high frequency currents make it possible to apply the latter in ways entirely impracticable with the former.

One of the prominent characteristics of high frequency or, to be more general, of rapidly varying currents, is that they pass with difficulty through stout conductors of high self-induction. So great is the obstruction which self-induction offers to their passage that it was found practicable, as shown in the early experiments to which reference has been made, to maintain differences of potential of many thousands of volts between two points—not more than a few inches apart—of a thick copper bar of inappreciable resistance. This observation naturally suggested the disposition illustrated in Fig. 3. The source of high frequency impulses is in this instance a familiar type of transformer which may be supplied from a generator G of ordinary direct or alternating currents. The transformer comprises a primary P, a secondary S, two condensers C C which are joined in series, a loop or coil of very thick wire L and a circuit interrupting device or break b. The currents are derived

[1] Read at the eighth annual meeting of The American Electro-Therapeutic Association, Buffalo, N. Y., Sept. 13 to 15, 1898.

from the loop L by two contacts c c', one or both of which are capable of displacement along the wire L. By varying the distance between these contacts, any difference of potential, from a few volts to many thousands, is readily obtained on the terminals or handles T T. This mode of using the currents is entirely safe and particularly convenient, but it requires a very uniform working of the break b employed for charging and discharging the condenser.

Another equally remarkable feature of high frequency impulses was found in the facility with which they are transmitted through condensers, moderate electromotive forces and very small capacities being required to enable currents of considerable volume to pass. This observation made it practicable to resort to a plan such as indicated in Fig. 4. Here the connections are similar to those shown in the preceding case, except that the condensers C C are joined in parallel. This lowers the frequency of the currents, but has the advantage of allowing the working with a much smaller difference of potential on the terminals of the secondary S. Since the latter is the chief item of expense of such apparatus and since its price rapidly increases with the number of turns required, the experimenter will find it generally cheaper to make a sacrifice in the frequency, which, however, will be high enough for most purposes. However, he only needs to reduce proportionately the number of turns or the length of primary p to obtain the same frequency as before, but the economy of transformation will be somewhat



FIGS. 5, 6, 7 AND 8.

reduced in so doing and the break b will require more attention. The secondary S^1 of the high frequency coil has two metal plates t t of considerable surface connected to its terminals, and the current for use is derived from two similar plates t' t' in proximity to the former. Both the tension and volume of the currents taken from terminals T T may be easily regulated and in a continuous manner by simply varying the distance between the two pair of plates t t and t' t' respectively.

A facility is also afforded in this disposition for raising or lowering the potential of one of the terminals T, irrespective of the changes produced on the other terminal, this making it possible to cause a stronger action on one or other part of the patient's body.

The physician may find it for some or other reason convenient to modify the arrangements in Figs. 2, 3 and 4 by connecting one terminal of the high frequency source to the ground. The effects will be in most respects the same, but certain peculiarities will be noted in each case. When a ground connection is made it may be of some consequence which of the terminals of the secondary is connected to the ground, as in high frequency discharges the impulses of one direction are generally preponderating.

Among the various noteworthy features of these currents there is one which lends itself especially to many valuable uses. It is the facility which they afford for conveying large amounts of electrical energy to a body entirely insulated in space. The practicability of this method of energy transmission, which is already receiving useful applications and promises to become of great importance in the near future, has helped to dispel the old notion assuming the necessity of a return circuit for the conveyance of electrical energy in any considerable amount. With novel appliances we are enabled to pass through a wire, entirely insulated on one end, currents strong enough to fuse it, or to convey through the wire any amount of energy to an insulated body. This mode of applying high frequency currents in medical treatment appears to me to offer the greatest possibilities at the hands of the physician. The effects produced in this manner possess features entirely distinct from those observed when the currents are applied in any of the before mentioned or similar ways.

The circuit connections as usually made are illustrated schematically in Fig. 5, which, with reference to the diagrams before shown, is self-explanatory. The condensers C C, connected in series, are preferably charged by a step-up transformer, but a high frequency alternator, static machine, or a direct current generator, if it be of sufficiently high tension to enable the use of small condensers, may be used with more or less success. The primary p, through which the high frequency discharges of the condensers are passed, consists of very few turns of cable of as low resistance as possible, and the secondary s, preferably at some distance from the primary to facilitate free oscillation, has one of its ends—that is the one which is nearer to the primary—connected to the ground, while the other end leads to an insulated terminal T, with which the body of the patient is connected. It is of importance in this case to establish synchronism between the oscillations in the primary and secondary circuits p and s respectively. This will be as a rule best effected by varying the self-induction of the circuit including the primary loop or coil p, for which purpose an adjustable self-induction e is provided; but in cases when the electromotive force of the generator is exceptionally high, as when a static machine is used and a condenser consisting of merely two plates offers sufficient capacity, it will be simpler to attain the same object by varying the distance of the plates.

The primary and secondary oscillations being in close synchronism, the points of highest potential will be on a part of terminal T, and the consumption of energy will occur chiefly there. The attachment of the patient's body to the terminal will in most cases very materially affect the period of oscillation in the secondary, making it longer, and a readjustment of the primary circuit will have to be made in each case to suit the capacity of the body connected with terminal T. Synchronism should always be preserved, and the intensity of the action varied by moving the secondary coil to or from the primary, as may be desired. I know of no method which would make it possible to subject the human body to such excessive electrical pressures as are practicable with this, or of one which would enable the conveying to and giving off from the body without serious injury amounts of electrical energy approximating even in a remote degree those which are entirely practicable when this manner of applying the energy is resorted to. This is evidently due to the fact that the action is chiefly superficial, the largest possible section being offered to the transfer of the current, or, to say more correctly, of the energy. With a very rapidly and smoothly working break I would not think it impossible to convey to the body of a person and to give off into the space energy at the rate of several horse power with impunity, while a small part of this amount applied in other ways could not fail to produce injury.

When a person is subjected to the action of such a coil, the proper adjustments being carefully observed, luminous streams are seen in the dark issuing from all parts of the body. These streams are short and of delicate texture when the number of breaks is very great and the action of the device b (Fig. 5) free of any irregularities, but when the number of breaks is small or the action of the device imperfect, long and noisy streams appear which cause some discomfort. The physiological effects produced with apparatus of this kind may be graduated from a hardly perceptible action when the secondary is at a great distance from the primary, to a most violent one when both coils are placed at a small distance. In the latter case only a few seconds are sufficient to cause a feeling of warmth all over the body, and soon after the person perspires freely. I have repeatedly, in demonstrations to friends, exposed myself longer to the action of the oscillations, and each time, after the lapse of an hour or so, an immense fatigue, of which it is difficult to give an idea, would take hold of me. It was greater than I experienced on some occasions after the most straining and prolonged bodily exertion. I could scarcely make a step and could keep the eyes open only with the greatest difficulty. I slept soundly afterward, and the after-effect was

certainly beneficial, but the medicine was manifestly too strong to be used frequently.

One should be cautious in performing such experiments for more than one reason. At or near the surface of the skin, where the most intense action takes place, various chemical products are formed, the chief being ozone and nitrogen compounds. The former is itself very destructive, this feature being illustrated by the fact that the rubber inslation of a wire is destroyed so quickly as to make the use of such insulation entirely impracticable. The compounds of nitrogen, when moisture is present, consists largely of nitric acid which might, by excessive application, prove hurtful to the skin. So far, I have not noted injuries which could be traced directly to this cause, though on several occasions burns were produced in all respects similar to those which were later observed and attributed to the Röntgen rays. This view is seemingly being abandoned, having not been substantiated by experimental facts, and so also is the notion that these rays are transverse vibrations. But while investigation is being turned in what appears to be the right direction, scientific men are still at sea. This state of things impedes the progress of the physicist in these new regions and makes the already hard task of the physician still more difficult and uncertain.

One or two observations made while pursuing experiments with the apparatus described might be found as deserving mention here. As before stated, when the oscillations in the primary and secondary cirucits are in synchronism, the points of highest potential are on some portion of the terminal T. The synchronism being perfect and the length of the secondary coil just equal to one-quarter of the wave length, these points will be exactly on the free end of terminal T, that is, the one situated farthest from the end of the wire attached to the terminal. If this be so and if now the period of the oscillations in the primary be shortened, the points of highest potential will recede towards the secondary coil, since the wave-length is reduced and since the attachment of one end of the secondary coil to the ground determines the position of the nodal points, that is, the points of least potential. Thus, by varying the period of vibration of the primary circuit in any manner, the points of highest potential may be shifted accordingly along the terminal T, which has been shown, designedly, long to illustrate this feature. The same phenomenon is, of course, produced if the body of a patient constitutes the terminal, and an assistant may by the motion of a handle cause the points of highest potential to shift along the body with any speed he may desire. When the action of the coil is vigorous, the region of highest potential is easily and unpleasantly located by the discomfort or pain experienced, and it is most curious to feel how the pain wanders up and down, or eventually across the body, from hand to hand, if the connection to the coil is accordingly made—in obedience to the movement of the handle controlling the oscillations. Though I have not observed any specific action in experiments of this kind, I have always felt that this effect might be capable of valuable use in electro-therapy.

Another observation which promises to lead to much more useful results is the following: As before remarked, by adopting the method described, the body of a person may be supjected without danger to electrical pressures vastly in excess of any producible by ordinary apparatus, for they may amount to several million volts, as has been shown in actual practice. Now, when a conducting body is electrified to so high a degree, small particles, which may be adhering firmly to its surface, are torn off with violence and thrown to distances which can be only conjectured. I find that not only firmly adhering matter, as paint, for instance, is thrown off, but even the particles of the toughest metals are torn off. Such actions have been thought to be restricted to a vacuous inclosure, but with a powerful coil they occur also in the ordinary atmosphere. The facts mentioned would make it reasonable to expect that this extraordinary effect which, in other ways, I have already usefully applied, will likewise prove to be of value in electro-therapy. The continuous improvement of the instruments and the study of the phenomenon may shortly lead to the establishment of a novel mode of hygienic treatment which would permit an instantaneous cleaning of the skin of a person, simply by connecting the same to, or possibly, by merely placing the person in the vicinity of a source of intense electrical oscillations, this having the effect of throwing off, in a twinkle of the eye, dust or particles of any extraneous matter adhering to the body. Such a result brought about in a practicable manner would, without doubt, be of incalculable value in hygiene and would be an efficient and time-saving substitute for a water bath, and particularly appreciated by those whose contentment consists in undertaking more than they can accomplish.

High frequency impulses produce powerful inductive actions and in virtue of this feature they lend themselves in other ways to the uses of the electro-therapeutist. These inductive effects are either electrostatic or electrodynamic. The former diminish much more rapidly with the distance—with the square of the same—the latter are reduced simply in proportion to the distance. On the other hand, the former grow with the square of intensity of the source, while the latter increase in a simple proportion with the intensity. Both of these effects may be utilized for establishing a field of strong action extending through considerable space, as through a large hall, and such an arrangement might be suitable for use in hospitals or institutions of this kind, where it is desirable to treat a number of patients at the same time.

Fig. 6 illustrates the manner, as I have shown it originally, in which such a field of electrostatic action is established. In this diagram G is a generator of currents of very high frequency, C a condenser for counteracting the self-induction of the circuit which includes the primary P of an induction coil, the secondary S of which has two plates t t of large surface connected

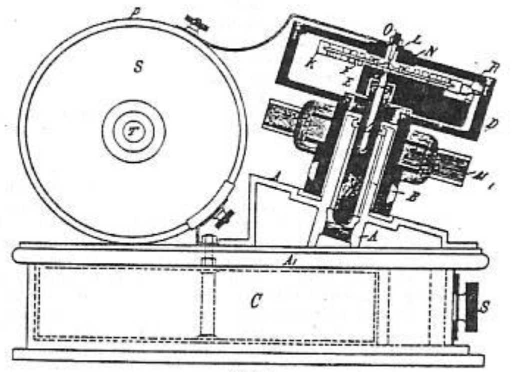


FIG. 9.

to its terminals. Well known adjustments being observed, a very strong action occurs chiefly in the space between the plates, and the body of a person is subjected to rapid variations of potential and surgings of current, which produce, even at a great distance, marked physiological effects. In my first experiments I used two metal plates as shown, but later I found it preferable to replace them by two large hollow spheres of brass covered with wax of a thickness of about two inches. The cables leading to the terminals of the secondary coil were similarly covered, so that any of them could be approached without danger of the insulation breaking down. In this manner the unpleasant shocks, to which the experimenter was exposed when using the plates, were prevented.

In Fig. 7 a plan for similarly utilizing the dynamic inductive effects of high frequency currents is illustrated. As the frequencies obtainable from an alternator are not as high as is desired, conversion by means of condensers is resorted to. The diagram will be understood at a glance from the foregoing description. It only need be stated that the primary p, through which the condensers are made to discharge, is formed by a thick stranded cable of low self-induction and resistance, and passes all around the hall. Any number of secondary coils s s s, each consisting generally of a single layer of rather thick wire, may be provided. I have found it practicable to use as many as one hundred, each being adjusted for a definite period and responding to a particular vibration passed through the primary. Such a plant I have had in use in my laboratory since 1892, and many times it has contributed to the pleasure of my visitors and also proved itself of practical utility. On a latter occasion I had the pleasure of entertaining some of the mem-

bers with experiments of this kind, and this opportunity I cannot let pass without expressing my thanks for the interest which was awakened in me by their visit, as well as for the generous acknowledgment of the courtesy by the Association. Since that time my apparatus has been very materially improved, and now I am able to create a field of such intense induction in the laboratory that a coil three feet in diameter, by careful adjustment, will deliver energy at the rate of one-quarter of a horse power, no matter where it is placed within the area inclosed by the primary loops. Long sparks, streamers and all other phenomena obtainable with induction coils are easily producible anywhere within the space, and such coils, though not connected to anything, may be utilized exactly as ordinary coils, and what is still more remarkable, they are more effective. For the past few years I have often been urged to show experiments in public, but, though I was desirous to comply with such requests, pressing work has so far made it impossible. These advances have been the result of slow but steady improvement in the details of the apparatus which I hope to be able to describe connectedly in the near future.

However remarkable the electrodynamic inductive effects, which I have mentioned, may appear, they may be still considerably intensified by concentrating the action upon a very small space. It is evident that since, as before stated, electromotive forces of many thousand volts are maintained between two points of a conducting bar or loop only a few inches long, electromotive forces of approximately the same magnitude will be set up in conductors situated near by. Indeed, I found that it was practicable in this manner to pass a discharge through a highly exhausted bulb, although the electromotive force required amounted to as much as ten or twenty thousand volts, and for a long time I followed up experiments in this direction with the object of producing light in a novel and more economical way. But the tests left no doubt that there was great energy consumption attendant to this mode of illumination, at least with the apparatus I had then at command, and, finding another method which promised a higher economy of transformation, my efforts turned in this new direction. Shortly afterward (some time in June, 1891,) Prof. J. J. Thomson described experiments which were evidently the outcome of long investigation, and in which he supplied much novel and interesting information, and this made me return with renewed zeal to my own experiments. Soon my efforts were centered upon producing in a small space the most intense inductive action, and by gradual improvement in the apparatus I obtained results of a surprising character. For instance, when the end of a heavy bar of iron was thrust within a loop powerfully energized, a few moments were sufficient to raise the bar to a high temperature. Even heavy lumps of other metals were heated as rapidly as though they were placed in a furnace. When a continuous band formed of a sheet of tin was thrust into the loop, the metal was fused instantly, the action being comparable to an explosion, and no wonder, for the frictional losses accumulated in it at the rate of possibly ten horse power. Masses of poorly conducting material behaved similarly, and when a highly exhausted bulb was pushed into the loop, the glass was heated in a few seconds nearly to the point of melting.

When I first observed these astonishing actions, I was interested to study their effects upon living tissues. As may be assumed, I proceeded with all the necessary caution, and well I might, for I had the evidence that in a turn of only a few inches in diameter an electromotive force of more than ten thousand volts was produced, and such high pressure would be more than sufficient to generate destructive currents in the tissue. This appeared all the more certain as bodies of comparatively poor conductivity were rapidly heated and even partially destroyed. One may imagine my astonishment when I found that I could thrust my hand or any other part of the body within the loop and hold it there with impunity. More than on one occasion, impelled by a desire to make some novel and useful observation, I have willingly or unconsciously performed an experiment connected with some risk, this being scarcely avoidable in laboratory experience, but I have always believed, and do so now, that I have never undertaken anything in which, according to my own estimation, the chances of being injured were so great as when I placed my head within the space in which such terribly destructive forces were at work. Yet I have done so, and repeatedly, and have felt nothing. But I am firmly convinced that there is great danger attending such an experiment, and some one going just a step farther than I have gone may be instantly destroyed. For, conditions may exist similar to those observable with a vacuum bulb. It may be placed in the field of the loop, however intensely energized, and so long as no path for the current is formed, it will remain cool and consume practically no energy. But the moment the first feeble current passes, most of the energy of the oscillations rushes to the place of consumption. If by any action whatever, a conducting path were formed within the living tissue or bones of the head, it would result in the instant destruction of these and death of the foolhardy experimenter. Such a method of killing, if it were rendered practicable, would be absolutely painless. Now, why is it that in a space in which such violent turmoil is going on living tissue remains uninjured? One might say the currents cannot pass because of the great self-induction offered by the large conducting mass. But this it cannot be, because a mass of metal offers a still higher self-induction and is heated just the same. One might argue the tissues offer too great a resistance. But this again cannot be the reason, for all evidence shows that the tissues conduct well enough, and besides, bodies of approximately the same resistance are raised to a high temperature. One might attribute the apparent harmlessness of the oscillations to the high specific heat of the tissue, but even a rough quantitative estimate from experiments with other bodies shows that this view is untenable. The only plausible explanation I have so far found is that the tissues are condensers. This only can account for the absence of injurious action. But it is remarkable that, as soon as a heterogeneous circuit is constituted, as by taking in the hands a bar of metal and forming a closed loop in this manner, the passage of the currents through the arms is felt, and other physiological effects are distinctly noted. The strongest action is, of course, secured when the exciting loop makes only one turn, unless the connections take up a considerable portion of the total length of the circuit, in which case the experimenter should settle upon the least number of turns by carefully estimating what he loses by increasing the number of turns, and what he gains by utilizing thus a greater proportion of the total length of the circuit. It should be borne in mind that, when the exciting coil has a considerable number of turns and is of some length, the effects of electrostatic induction may preponderate, as there may exist a very great difference of potential—a hundred thousand volts or more—between the first and last turn. However, these latter effects are always present even when a single turn is employed.

When a person is placed within such a loop, any pieces of metal, though of small bulk, are perceptibly warmed. Without doubt they would be also heated—particularly if they were of iron—when embedded in living tissue, and this suggests the possibility of surgical treatment by this method. It might be possible to sterilize wounds, or to locate, or even to extract metallic objects, or to perform other operations of this kind within the sphere of the surgeon's duties in this novel manner.

Most of the results enumerated, and many others still more remarkable, are made possible only by utilizing the discharges of a condenser. It is probable that but a very few—even among those who are working in these identical fields—fully appreciate what a wonderful instrument such a condenser is in reality. Let me convey an idea to this effect. One may take a condenser, small enough to go in one's vest pocket, and by skilfully using it he may create an electrical pressure vastly in excess—a hundred times greater if necessary—than any producible by the largest static machine ever constructed. Or, he may take the same condenser and, using it in a different way, he may obtain from it currents against which those of the most powerful welding machine are utterly insignificant. Those who are imbued with popular notions as to the pressures of static machines and currents obtainable with a commercial transformer, will be astonished at this statement—yet the truth of it is easy to see. Such results are obtainable, and easily, because the condenser can discharge the stored energy in an inconceivably short time. Nothing like this property is known in physical science. A compressed spring, or a storage battery, or any other form of device capable of storing energy, cannot do this; if they could, things undreamt of at present might be accomplished by their means. The nearest approach to a charged condenser is a high explosive, as dynamite. But even the most violent explosion of such a compound bears no comparison with the discharge or explosion of a condenser. For, while the pressures which are produced in the detonation of a chem-

ical compound are measured in tens of tons per square inch, those which may be caused by condenser discharges may amount to thousands of tons per square inch, and if a chemical could be made which would explode as quickly as a condenser can be discharged under conditions which are realizable—an ounce of it would quite certainly be sufficient to render useless the largest battleship.

That important realizations would follow from the use of an instrument possessing such ideal properties I have been convinced since long ago, but I also recognized early that great difficulties would have to be overcome before it could replace less perfect implements now used in the arts for the manifold transformations of electrical energy. These difficulties were many. The condensers themselves, as usually manufactured, were inefficient, the conductors wasteful, the best insulation inadequate, and the conditions for the most efficient conversion were hard to adjust and to maintain. One difficulty, however, which was more serious than the others, and to which I called attention when I first described this system of energy transformation, was found in the devices necessarily used for controlling the charges and discharges of the condenser. They were wanting in efficiency and reliability and threatened to prove a decided drawback, greatly restricting the use of the system and depriving it of many valuable features. For a number of years I have tried to master this difficulty. During this time a great number of such devices were experimented upon. Many of them promised well at first, only to prove inadequate in the end. Reluctantly, I came back upon an idea on which I had worked long before. It was to replace the ordinary brushes and commutator segments by fluid contacts. I had encountered difficulties then, but the intervening years in the laboratory were not spent in vain, and I made headway. First it was necessary to provide for a circulation of the fluid, but forcing it through by a pump proved itself impractical. Then the happy idea presented itself to make the pumping device an integral part of the circuit interrupter, inclosing both in a receptacle to prevent oxydation. Next some simple ways of maintaining the circulation, as by rotating a body of mercury, presented themselves. Then I learned how to reduce the wear and losses which still existed. I fear that these statements, indicating how much effort was spent in these seemingly insignificant details will not convey a high idea of my ability, but I confess that my patience was taxed to the utmost. Finally, though, I had the satisfaction of producing devices which are simple and reliable in their operation, which require practically no attention and which are capable of effecting a transformation of considerable amounts of energy with fair economy. It is not the best that can be done, by any means, but it is satisfactory, and I feel that the hardest task is done.

The physician will now be able to obtain an instrument suitable to fulfil many requirements. He will be able to use it in electro-therapeutic treatment in most of the ways enumerated. He will have the facility of providing himself with coils such as he may desire to have for any particular purpose, which will give him any current or any pressure he may wish to obtain. Such coils will consist of but a few turns of wire, and the expense of preparing them will be quite insignificant. The instrument will also enable him to generate Röntgen rays of much greater power than obtainable with ordinary apparatus. A tube must still be furnished by the manufacturers which will not deteriorate and which will allow to concentrate larger amounts of energy upon the electrodes. When this is done, nothing will stand in the way of an extensive and efficient application of this beautiful discovery which must ultimately prove itself of the highest value, not only at the hands of the surgeon, but also of the electro-therapist and, what is most important, of the bacteriologist.

To give a general idea of an instrument in which many of the latter improvements are embodied, I would refer to Fig. 9, which illustrates the chief parts of the same in side elevation and partially in vertical cross-section. The arrangement of the parts is the same as in the form of instrument exhibited on former occasions, only the exciting coil with the vibrating interrupter is replaced by one of the improved circuit breakers to which reference has been made.

This device comprises a casting A with a protruding sleeve B, which in a bushing supports a freely rotatable shaft a. The latter carries an armature within a stationary field magnet M and on the top, a hollow iron pulley D, which contains the break proper. Within the shaft a, and concentrically with the same, is placed a smaller shaft b, likewise freely movable on ball-bearings and supporting a weight E. This weight being on one side and the shafts a and b inclined to the vertical, the weight remains stationary as the pulley is rotated. Fastened to the weight E is a device R in the form of a scoop with very thin walls, narrow on the end nearer to the pulley and wider on the other end. A small quantity of mercury being placed in the pulley and the latter rotated against the narrow end of the scoop, a portion of the fluid is taken up and thrown in a thin and wide stream towards the centre of the pulley. The top of the latter is hermetically closed by an iron washer, as shown, this washer supporting on a steel rod L a disk F of the same metal provided with a number of thin contact blades K. The rod L is insulated by washers N from the pulley, and for the convenience of filling in the mercury a small screw o is provided. The bolt L forming one terminal of the circuit breaker is connected by a copper strip to the primary p. The other end of the primary coil leads to one of the terminals of the condenser C, contained in a compartment of a box A, another compartment of the same being reserved for switch S and terminals of the instrument. The other terminal of the condenser is connected to the casting A and through it to pulley D. When the pulley is rotated, the contact blades K are brought rapidly in and out of contact with the stream of mercury, thus closing and opening the circuit in quick succession. With such a device it is easy to obtain ten thousand makes and breaks per second and even more. The secondary s is made of two separate coils and so arranged that it can be slipped out, and a metal strip in its middle connects it to the primary coil. This is done to prevent the secondary from breaking down when one of the terminals is overloaded, as it often happens in working Röntgen bulbs. This form of coil will withstand a very much greater difference of potential than coils as ordinarily constructed.

The motor has both field and armature built of plates, so that it can be used on alternating as well as direct current supply circuits, and the shafts are as nearly as possible vertical, so as to require the least care in oiling. Thus, the only thing which really requires some attention is the commutator of the motor, but where alternating currents are always available, this source of possible trouble is easily done away with.

The circuit connections of the instrument have been already shown and the mode of operation explained in periodicals. The usual manner of connecting is illustrated in Fig. 8, in which A_1 A_1 are the terminals of the supply circuit, L, a self-induction coil for raising the pressure, which is connected in series with condenser C and primary P P. The remaining letters designate the parts correspondingly marked in Fig. 9 and will be understood with reference to the latter.

No. 623,316. Patented Apr. 18, 1899.

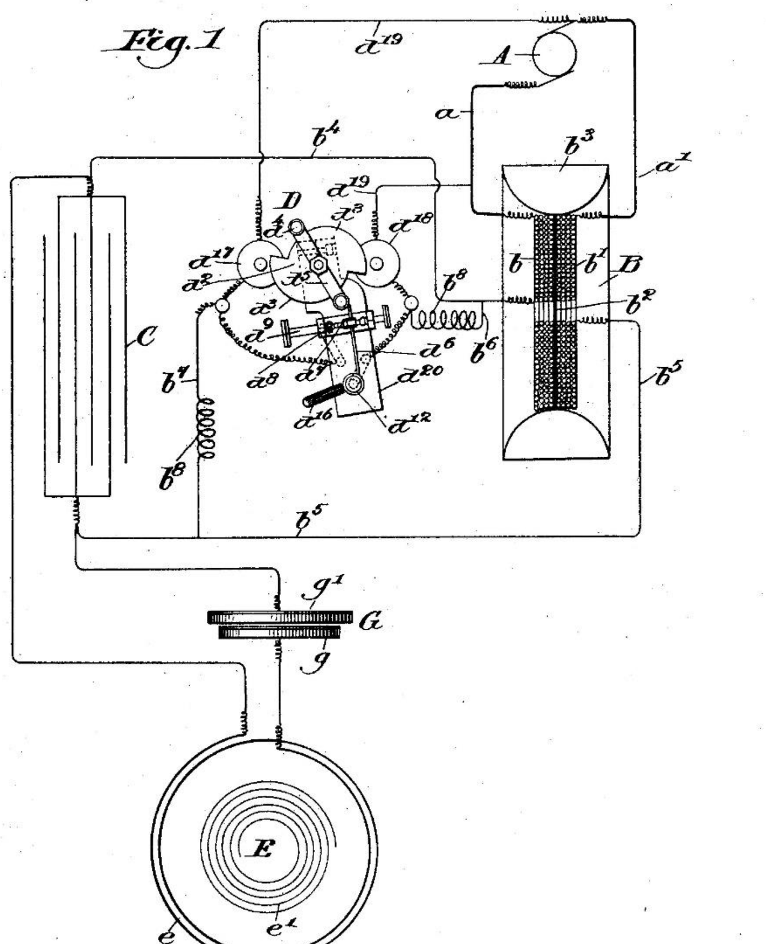
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INDUCTION APPARATUS.

(Application filed May 5, 1898.)

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Fig. 1



Witnesses:

A. O. Harmon

Fred S. Grunleaf

Inventor:

Thomas B. Kinraide

by Crosby & Gregory

Attys.

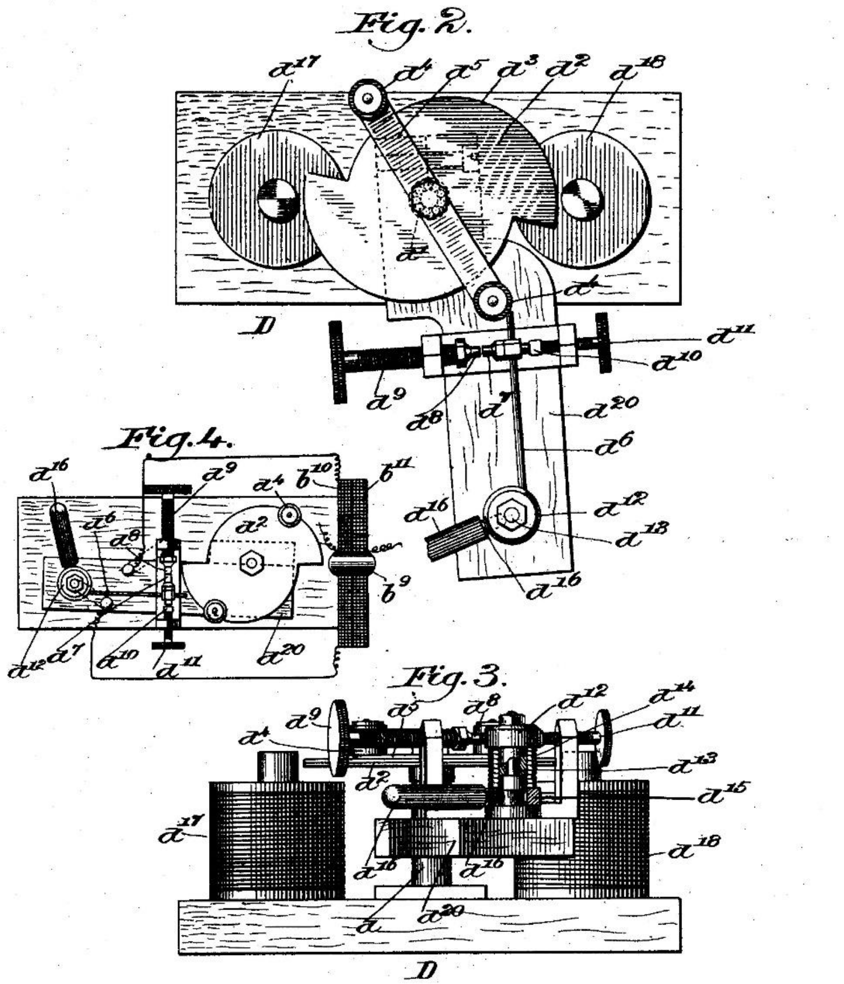
No. 623,316. Patented Apr. 18, 1899.

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INDUCTION APPARATUS.

(Application filed May 5, 1898.)

(No Model.) 3 Sheets—Sheet 2.



Witnesses:
A. C. Harmon
Fred S. Grunleaf

Inventor.
Thomas B. Kinraide
by Crosby & Gregory
attys.

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No. 623,316. Patented Apr. 18, 1899.

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INDUCTION APPARATUS.

(Application filed May 5, 1898.)

(No Model.) 3 Sheets—Sheet 3.

Fig. 5.

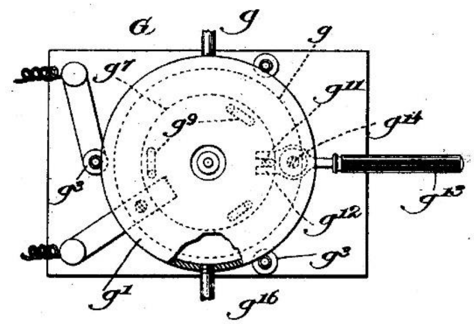
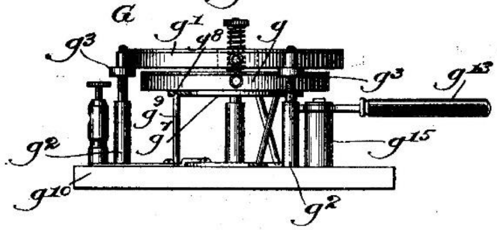


Fig. 6.



Witnesses:

A.C. Harmon.

Fred S. Greenleaf.

Inventor:

Thomas B. Kinraide

by Crosby & Gregory

attys.

UNITED STATES PATENT OFFICE.

THOMAS B. KINRAIDE, OF BOSTON, MASSACHUSETTS.

INDUCTION APPARATUS.

SPECIFICATION forming part of Letters Patent No. 623,316, dated April 18, 1899.

Application filed May 5, 1898. Serial No. 679,799. (No model.)

To all whom it may concern:

Be it known that I, THOMAS B. KINRAIDE, of Boston, county of Suffolk, State of Massachusetts, have invented an Improvement in Induction Apparatus, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My invention is an improved induction apparatus whereby discharges are made possible of greater efficiency, as will more fully appear in the course of the following description.

I will describe the details of my invention with reference to the accompanying drawings, which illustrate a preferred form of the apparatus.

In the drawings, Figure 1 is a view, partly diagrammatic and partly in section and plan, illustrating the arrangement of the system according to my invention. Fig. 2 is a top plan view of the break. Fig. 3 is a front elevation thereof, parts being broken away to show the detailed construction. Fig. 4 is a view similar to Fig. 2, showing a modified form thereof. Fig. 5 is a top plan view of my improved spark-gap. Fig. 6 shows the spark-gap in elevation.

Heretofore there has always been a considerable amount of waste energy in systems for developing high potential, and also there has been an ever-present danger of breaking down and destroying the apparatus by its own output, and accordingly it has been my present aim to provide a system in which all the increase of potential which may be developed shall be delivered for use for the translating devices and in which the apparatus is self-containing and practically indestructible.

Let A designate a dynamo, battery, or any other suitable source of electrical energy. From the dynamo the current passes by conductors $a\ a'$ to an inductance device B, each conductor $a\ a'$ having its own coil $b\ b'$, said coils being preferably insulated from each other, as indicated at b^2, and surrounded by a laminated core b^3. Each coil b is wound transversely back and forth until the opposite terminals $b^4\ b^5$ reach the center and are thence carried to the opposite ends of a condenser C, a break D being interposed and connected to the main conductors $b^4\ b^5$ at $b^6\ b^7$ and the discharge from the condenser being received by a translating device (herein shown as a special induction-coil E) by means of an automatic spark-gap G.

Each one of the details of apparatus above enumerated as constituting my system is of special construction and peculiar effect in the system, whereby it becomes possible to discharge currents of considerable strength with great velocity through the primary of the coil E, the discharge across the spark-gap being of very great amperage and exceedingly short and sharp oscillations.

Referring now to the inductance device B, I will explain that the object of this device is to raise the potential of the current and cause all this increase of potential to pass to the condenser, preventing any of it from discharging through the dynamo.

By my device the total potential is delivered only from the forward end of the wire or the one toward the condenser, and also there is only one end of the coil which has high potential. This is because the lines of magnetic force occasioned by the flow of the electric current, which during said flow are radiated from the core or field b^3, fall from the center across all the turns of wire into the periphery as the circuit is interrupted, and hence maintain a region of constant magnetic intensity at the periphery, effectually checking all rise of potential at that end, but leaving the opposite or outgoing end free from the presence of the lines of magnetic force as soon as the break occurs, and therefore without impedance. As soon as the current is broken the lines of force fall back toward the iron core and leave the central portion of the coil free from the restraining influence of these lines of force, said lines cutting across the successive turns of wire, the coil being left free to permit the induced current of increased potential to flow toward the center of the coils or toward that point which has no magnetic field whatever to choke back the current, thereby permitting the latter to rush out unconfined and unrestrained toward its natural outlet; but as the lines of the magnetic field are constantly maintained with maximum impedance at the periphery of the coil and remain surrounding the peripheral turns until the very last moment of the fall due to the break in the circuit their presence

there prohibits any possibility of manifestation of the rise of the potential in the current at that end of the coil, so that all the increase of potential in the whole coil is obliged to find an outlet from the center, and the ease of outflow from this outlet increases as the lines of force fall away from the center, thereby removing their restraining and impeding influence therefrom. This will be clear by bearing in mind the action which takes place in what is commonly called a "choke-coil"—*i. e.*, a winding about an iron core, said winding being in a spiral from one end of the iron to the other. In such a coil it is obvious that when a current passes the lines of force rise equally along the extent of the entire coil and that when the current is broken the lines of force fall directly in, perpendicular to the core, thereby cutting each turn of the spiral equally and at the same time, thereby producing high pressure at both ends of the choke-coil, the potential being necessarily the same at both ends of the wire, because both ends are affected by the same conditions of falling lines of force.

In my coil the lines of force do not fall equally on all the turns; but there is a minimum intensity at the center and a maximum intensity at the periphery, the latter being the point of entrance of the current, so that the current due to self-induction is always free to be drawn off, as it were, into the condenser at one end as fast as it is developed and is prevented from departing at the opposite end, or, stated in other words, while the current from the dynamo is always free to flow into the coil for having its potential raised the said potential must all seek its outlet at the opposite end of the coil, so that all the current of the coil flows therefrom into the condenser, whereas in a choke-coil the induced current may be said to ooze out at both ends, so that the benefit is not received of all that is developed.

By my coil all the lines of force are collected for cutting from the center across the entire coil, whereas in the usual choke-coil the lines of force that fall at the center cut only the central turns, so that in my coil I develop all the potential that is possible to be developed.

I regard it as a new principle to withdraw the lines of magnetic force away from that portion of the coil from which the current is being drawn and maintain a magnetic field at that portion of the coil which receives the current.

Other features of construction to be noted in the coil shown in Fig. 1 are that the high-potential end of the coil is that portion of least resistance, because the central turns are of course shorter than the peripheral turns. The resistance in the coil diminishes as the potential increases; also, it will be observed that I have given the magnetic core substantially the form of a semicircle in cross-section, my reason for this form being that thereby the lines of magnetic force are given their best radiation or are distributed to the best effect on the coil, it being understood that these lines leave the iron perpendicular to its surface and are gradually bent around toward the coil.

Referring now to the break D, (best shown in Figs. 2 and 3,) I journal in a central post or bearing d the spindle d' of an iron plate or armature d^2, having two or more eccentric edges d^3, as clearly shown in Fig. 2, or other provision of regions of increasing magnetic attraction. Mounted on or otherwise connected to rotate therewith are one or more small antifriction-rolls d^4, two being herein shown mounted at the opposite ends of a bar d^5, clamped adjustably on the plate d^2. These rolls or circuit-interrupters are preferably of indurated fiber. Mounted to extend into the path of the rolls d^4 is an arm (shown as a wire d^6) carrying a hammer d^7 to contact with an anvil d^8 on a post d^9 and limited in its movement by a fiber stop d^{10} on the end of an adjusting-screw d^{11}. The wire d^6 is carried by a hub d^{12}, loose on a pin d^{13} and held under tension by a spring-coil d^{14}, Fig. 3, fastened at one end to said hub and at its other end to a nut d^{15}, carrying an adjusting or set screw d^{16}, so that by loosening the set-screw and swinging its handle one way or the other the resistance of the arm d^6 may be varied. Opposite the surfaces d^3 I place solenoids or electromagnets d^{17} d^{18}, operated by taps d^{19} from the main circuit entering the solenoids at their inner terminals, so that as the magnets d^{17} d^{18} are energized they attract the plate d^2, and by the increasing pull exerted thereon on account of the eccentric surfaces d^3 they cause the plate to rotate with a speed only checked by the striking of the interrupters d^4 against the end of the arm d^6, said rolls being placed relatively to the highest points of the surfaces d^3, so that they cut off the current just before said highest points get opposite the propelling-magnets, thereby permitting the momentum of the plate or armature d^2 to carry said highest points beyond the magnets sufficiently to prevent the latter exerting any retarding influence on the rotation of the break. Preferably I mount the anvil and hammer on a swinging ledge or carrier d^{20}, journaled on the post d, so that I am enabled to regulate the speed of the break simply by swinging the carrier d^{20} one way or the other. The same effect may be obtained by shifting the roll or rolls d^4 on the plate d^2, provided they are carried, as preferred, on a bar d^5, so that they can be shifted; but this adjustment cannot of course take place while the apparatus is in operation, and therefore for instantaneous regulation of the apparatus and of the system I provide the swinging carrier d^{20}. A movement of the carrier from right to left in the diagram causes the current to be broken before the armature has reached its point of greatest attraction, and as it is moved farther toward the left the

pull on the armature exerted by the magnets is diminished more and more and the speed of rotation of the armature is correspondingly reduced, thereby reducing the number of breaks and at the same time lengthening the time which the circuit of the inductance-coil is closed. This is of great importance, because thereby it results that the degree of magnetic saturation of the core or field b^8 may be increased up to its highest limit.

I place the arm or wire d^6 slightly tangential to the armature, as will be seen viewing Fig. 2, in order that the rolls d^4 may strike the extreme end thereof with least friction, striking outward instead of square against the end.

The mains b^4 b^5, Fig. 1, are connected, as stated, to the break by the conductors b^6 b^7, and in order that the condenser may not discharge back through the break I interpose in these conductors a resistance, herein shown as consisting of a few small turns b^8. The discharge from the condenser will seek the path of least resistance, and therefore I interpose just sufficient resistance at b^8 to prevent said discharge acting through the break, but not enough to render the condenser inoperative. One object of this special break is to make it possible to get all the efficiency out of the inductance apparatus B that there is. This would be impossibe with any usual break, for the reason that if a usual break were used, so as to give an equivalent period in which the circuit was closed, the brush would remain upon the surface of the break, tending through the heat or friction engendered to arc upon it, so that the condenser could not receive the full charge from the inductance-coil, but a portion would be lost upon the break-surface. My break, however, gives an absolutely instantaneous break, this break, moreover, being of extremely short duration, so that in practice I am enabled to leave the circuit closed during thirty-five thirty-sixths of the period of rotation of the break-armature, thereby leaving the inductance-coil B all of this period in which to raise its potential. It will be understood that as the point of highest saturation of the core is approached the discharge into the condenser is much greater in volume than if the magnetic flux were not complete.

In my break there is not only no chance for it to arc, as there is no surface for it to arc over, but the break itself is so exceedingly quick that there is not even a spark at the time of break, but there is merely occasionally a residual spark upon the closing of the break. Thus I am enabled to avoid entirely the considerable loss of energy heretofore consumed by the break, and I am enabled by the use of this break, in connection with the special inductance-coil B, to charge the condenser with an amperage which has not been possible in any system heretofore. Also by reason of the spark-gap G, which I will now describe, I am enabled to maintain the condenser action at the maximum charge and without any danger of breaking it down.

I provide electrodes in the form of opposite parallel disks g g', the air-gap between whose plane surfaces constitutes the spark-gap, the extended area of these electrodes preventing the tendency of the condenser to discharge until it has reached its maximum charge, and also causing the discharge to be exceedingly sudden when it does take place and the disks not being liable to become unduly heated. The spark-gap G constitutes virtually a self-recuperative or indestructible condenser, as it were, the parallel and preferably plane metallic surfaces g g' being the discharge-surfaces which discharge through or across the intervening air-dielectric. The air-gap is broken through when the voltage has exerted a sufficient strain upon the air to rupture it. The larger the disks are the farther apart they will spark. At each discharge of the condenser a small portion of these plates is oxidized, the successive discharges producing very thin oxidation here and there until the entire surfaces of the two disks are completely oxidized. Referring to Figs. 5 and 6 for the details of this spark-gap, it will be seen that I provide a plurality of posts g^2, threaded at their upper ends and carrying shouldered nuts g^3, on the shoulders of which is placed the top disk g', being held accurately on said shoulders by a spring g^4 under a tension-nut g^5, said nut and spring being mounted on the reduced end of a central post g^6, over which the plates g g' are placed. The opposite plate g rests on a support or table g^7, provided on its under side with a plurality of recesses or sockets g^8, herein shown as three in number, which receive props or struts g^9, projecting upwardly from the base g^{10} of the instrument. These props g^9 are of precisely equal length, so that they support the plate g in absolute parallelism to its opposite plate g'. The support g^7 has depending from its lower side a stud g^{11}, which is engaged by the bifurcated end g^{12} of a lever g^{13}, pivoted at g^{14} to a post g^{15} on the base. By this provision the most delicate adjustment is possible simply by swinging the lever g^{13} one way or the other, so as to incline the struts g^9 more or less, and thereby increase or decrease the distance between the plates g g', the nuts g^3 being depended upon for the coarser adjustments of the plates.

I have shown the plates g g' as hollow and provided with water-circulation pipes g^{16} in order that they may be absolutely prevented from all heating under extraordinary conditions.

The induction-coil E comprises a primary e of large cross-sectional area, capable of receiving a considerable amperage, the secondary e' being wound on the principle explained in connection with the coils b b', so that its inner terminal alone has the high-potential

discharge, the other terminal having comparatively no discharge. I do not herein claim this induction-coil, inasmuch as it forms the subject of another application and is therein claimed; nor will I herein further describe the details thereof, merely showing this particular coil for the reason that this is the only coil known to me which can be used for obtaining the best results from my system; nor do I herein claim the special break device, nor the special spark-gap, inasmuch as these form the subjects-matter of other applications, Serial Nos. 691,757 and 691,758, filed September 24, 1898, and are therein claimed, and it will accordingly be understood that while these particular instruments are preferably employed in my system I do not intend to restrict the latter thereto, nor otherwise than as expressed in the following claims. The conditions that are obtained in this system make it possible to discharge currents of enormous strength with great velocity through the primary, the velocity obtained making it possible to raise the potential in the secondary enormously, and the said potential being confined to one terminal only a resulting discharge is obtained representing the total of the potential that otherwise would be manifest at both terminals of an ordinary coil.

The spark-gap G is adjusted to the point of discharge of the condenser which it is desired the latter should maintain, and accordingly said condenser is automatically discharged as often as it rises to said point of maximum charge, and it can never be overcharged, for the reason that the spark-gap remains unvarying.

The use of the plates g g' makes possible the sudden discharge of the condenser after it has reached the certain predetermined point mentioned, and said discharge is of great volume or large amperage and of a very sudden and abrupt nature, as the current will not break across the spark-gap until it cannot help doing so, and when it does do so the discharge takes place with a minimum heating effect, not interfering with the efficiency, with very rapid and with very short and sharp oscillations, incapable of being obtained between a ball or point discharge-gap and productive of very great results in the secondary.

The plates g g' of the gap G are adjusted to the potential at which it is desired the condenser C shall discharge, and then the break D is regulated to give the volume or amperage of current which it is desired shall charge the condenser, the latter being automatically discharged as frequently as its charge reaches the predetermined limit to which the spark-gap has been adjusted. For example, supposing that the break D is adjusted so as to require the inductance device B to operate at its saturated point, as before explained. Then the number of discharges of the condenser across the spark-gap during each fluctuation in the coil B will be many more times than if the break D were operating more rapidly, and hence the rapidity of the discharge from the induction-coil E is increased in its efficiency, giving more volume of discharge.

It must be understood that the potential that is developed in the induction-coil E is not as great when the plates g g' are brought near together as it is when they are far apart, because in the latter case the condenser charge becomes greater necessarily before it is discharged. By increasing the length of the spark-gap, the speed of the break remaining the same, I get an increase of potential in the oscillator or induction-coil E, and also I may obtain the same effect without varying the length of spark-gap by decreasing the speed of the break.

The maximum potential obtainable from the induction-coil is when the break is adjusted to rotate at a speed sufficient to permit the saturation of the core b^3 and the spark-gap at G is lengthened so that the condenser is allowed to charge to its full capacity.

The sudden opening of the break-gap wide enough so that no discharge may take place thereat, but all the charge seeks a much better channel of discharge in the condenser, taking place as it does in an exceedingly small interval of the period of rotation of the break, gives the inductance-coil B volume of discharge such that it may charge the condenser a considerable number of times before another break takes place; or, to put this in another way, my apparatus enables me to produce a charge from the device B of such enormous volume that the spark-gap G will be called upon to automatically discharge the condenser a number of times during the interval of one falling of the lines of force in the inductance device B.

I regard myself as the first to provide an induction system capable of automatically regulating itself so as to maintain a given discharge, and I also believe myself to be the first to provide an apparatus capable of maintaining said condenser-discharge at a given amperage.

The frequency by my system is practically unlimited, inasmuch as a plurality of inductance devices B may be connected independently to the break D and condenser C, merely being arranged to operate out of step with each other, and there will be no danger to the condenser, for the reason that the spark-gap G will take care of all the charge which may be delivered to the condenser.

My system enables me to use a small condenser and yet with enormous efficiency therefrom.

While I have herein described preferred embodiments of my invention, I do not restrict myself thereto. For example, the electromagnets d^{17} d^{18} need not be used; but instead thereof the inductance device B may be oppositely wound, as indicated in Fig. 4, so that the core b^3 will be properly located for

running the armature d^2 of the break. In this case I make the ends of the core b^9 hemispherical, thereby obtaining the same advantage before explained in connection with the similarly-shaped surfaces of the core b^3, and the coils b^{10} b^{11} will be wound back and forth transversely in the same manner as the coils b b', the difference being that in this case the inner terminal becomes the low-potential end of the coils for connection to the dynamo and the outer terminals are the high-potential ends of the coils for connection to the condenser, this form of apparatus, however, not being so efficient as the form previously described, for the reason that the outer or longer turns present an increased resistance to the higher potential, whereas the best effects can be obtained, as before explained, by presenting a decreasing resistance to an increasing potential.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a system of the kind described, an electric circuit, means including a condenser to impress thereon a current of high frequency, combined with means for automatically discharging the condenser at any predetermined degree of charge, and means for varying the amperage charge of the condenser, substantially as described.

2. In a system of the kind described, a source of electrical energy, and a condenser, combined with a device for raising the potential of the current, means for discharging said raised potential solely in one direction from said device, and means for controlling the potential of said device, substantially as described.

3. In a system of the kind described, a source of electrical energy, a break, condenser, and a translating device to receive the discharge from the condenser, combined with means for preventing the discharge of the condenser back through the break, substantially as described.

4. In a system of the kind described, the combination with a source of electrical energy, a break, and condenser, of an inductance device between said source of energy and the break, said device having a magnetic core, and coils in the influence of said core and wound to present high potential at one end and low potential at the other end, said coils having their low-potential terminals connected to the source of energy, and their high-potential terminals connected to the condenser, and interrupted by the break, substantially as described.

5. In a system of the kind described, the combination with a source of electrical energy, a break, and condenser, of an inductance device between said source of energy and the break, said device having a core producing a magnetic field, and coils in the influence of said field and wound to present high potential at one end and low potential at the other end, said coils having their low-potential terminals connected to the source of energy, and their high-potential terminals connected to the condenser, and interrupted by the break, and means to vary the degree of magnetic saturation of said field in the operation of the system, substantially as described.

6. In a system of the kind described, a source of electrical energy, a break, and a condenser, combined with means independent of the break for automatically regulating the frequency of discharge from said condenser, substantially as described.

7. In a system of the kind described, a source of electrical energy, an inductance device for raising the potential of the current therefrom, said device delivering said potential in one direction only and away from the source of energy, a break provided with means for maintaining long intervals of closed circuit, and sudden short intervals of break, a condenser, and an automatic discharge device for said condenser, substantially as described.

8. In a system of the kind described, a source of electrical energy, an inductance device for raising the potential of the current therefrom, said device delivering said potential in one direction only and away from the source of energy, a break provided with means for maintaining long intervals of closed circuit, and sudden short intervals of break, a condenser, means preventing back discharge from the condenser and sparking at the break, and an automatic discharge device for said condenser, substantially as described.

9. The combination in an electrical circuit, of an inductance-coil having a core producing a magnetic field and wound to present a high-potential region at one end and low-potential region at the other end, the terminal thereof connected with the source of current-supply being at said low-potential region, and the opposite terminal being at said high-potential region, said coil having the potential thereof decreasing in a constant ratio from the one to the other terminal, and mechanism for interrupting the said circuit, said mechanism comprising means for maintaining the circuit closed in periods sufficient to fully charge said magnetic field, substantially as described.

10. An inductance-coil comprising a core, and a winding of current-conductor centrally of said core, said winding being in two coils, each having one terminal adjacent said core and the other terminal removed from said core, with all the windings of the coil located between said two terminals, and said coil having its potential varying per turn progressively in a constant ratio throughout its length from one terminal to the other terminal, substantially as described.

11. In an inductance-coil, a peripheral core or magnetic body, and a winding of current-conductor within the field of said magnetic body, said conductor being wound to present

its successive layers of windings successively shorter from the periphery to the center of the coil throughout the entire length of the conductor, substantially as described.

12. In an inductance device, a magnetic core, and a coil adjacent thereto, said core presenting curved surfaces adjacent the coil curving therefrom in a direction away from the coil, whereby the lines of magnetic force leaving the core perpendicular to said surfaces are widely distributed about the coil, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THOMAS B. KINRAIDE.

Witnesses:
GEO. H. MAXWELL,
FREDERICK L. EMERY.

No. 623,317. Patented Apr. 18, 1899.

T. B. KINRAIDE.

ELECTRICAL BREAK.

(Application filed Sept. 24, 1898.)

(No Model.)

Fig:1.

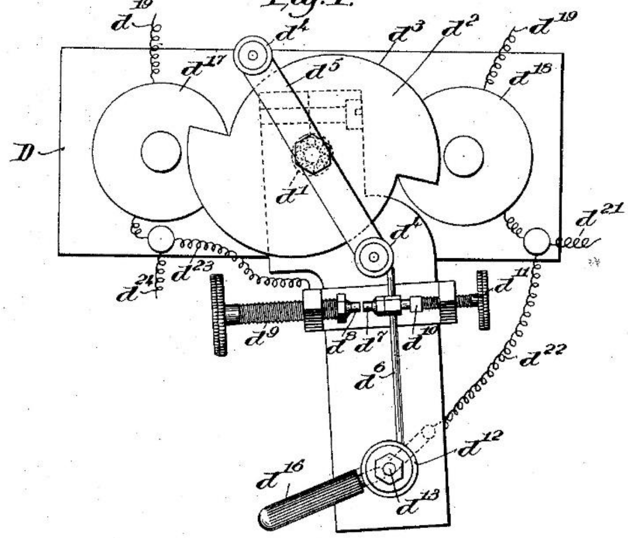
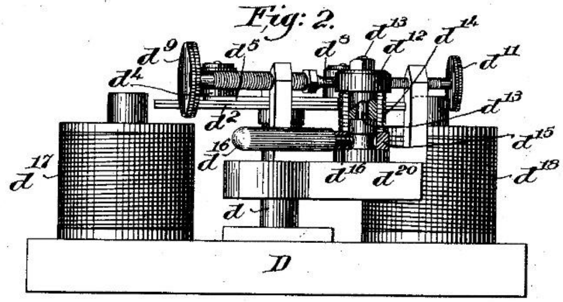


Fig: 2.



Witnesses,
Edward F. Allen.
Fred S. Greenleaf

Inventor,
Thomas B. Kinraide,
by Crosby Gregory.
Att'ys.

UNITED STATES PATENT OFFICE.

THOMAS B. KINRAIDE, OF BOSTON, MASSACHUSETTS.

ELECTRICAL BREAK.

SPECIFICATION forming part of Letters Patent No. 623,317, dated April 18, 1899.

Original application filed May 5, 1898, Serial No. 679,799. Divided and this application filed September 24, 1898. Serial No. 691,757. (No model.)

To all whom it may concern:

Be it known that I, THOMAS B. KINRAIDE, of Boston, county of Suffolk, State of Massachusetts, have invented an Improvement in Electric Breaks, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My present application is a division of my application, Serial No. 679,799, filed May 5, 1898.

Electric breaks as heretofore provided have been subject to considerable sparking, which is not only destructive of the apparatus, but is very objectionable in its effects on the current and system being operated, this being especially true of rotary breaks which operate by means of a brush in frictional engagement with a rotating surface. Accordingly I have invented a break in which there is no chance for arcing, as there is no surface to arc over, and also a leading object of my break is to provide a means for making an exceedingly quick break with a relatively long period of closed circuit, my break rendering it possible to regulate the period of closed circuit accurately. Many considerable advantages resulting from this construction will occur to those skilled in the art.

The details of construction and principles of operation of my improved break will be more fully pointed out in the following description, reference being had to the accompanying drawings, in which I have illustrated a preferred embodiment of my invention, and the latter will be more particularly defined in the appended claims.

In the drawings, Figure 1 is a top plan view of one form of my break. Fig. 2 shows the same in elevation.

On a suitable base D, I journal, in a central post or bearing d, a spindle d' of an iron plate or armature d^2, having two or more regions of varying mass of magnetic material, herein shown in the form of eccentric edges d^3, as clearly shown in Fig. 1.

My object is to provide regions of increasing magnetic attraction to coöperate with one or more suitable electromagnets or solenoid devices so located as to successively attract these regions of varying mass of magnetic material for rotating the armature, as will now be explained.

Mounted on or otherwise connected to rotate with the armature d^2 are one or more small antifriction-rolls d^4, two being herein shown mounted at the opposite ends of a bar d^5, clamped adjustably on the plate d^2. These rolls or circuit-interrupters are preferably of indurated fiber.

Mounted to extend into the path of the rolls d^4 is an arm, (shown as a wire d^6,) carrying a hammer d^7 to contact with an anvil d^8 on a post d^9 and limited in its movement by a fiber stop d^{10} on the end of an adjusting-screw d^{11}. The wire d^6 is carried by a hub d^{12}, loose on a pin d^{13} and held under tension by a spring-coil d^{14}, Fig. 2, fastened at one end to said hub and at its other end to a nut d^{15}, carrying an adjusting or set screw d^{16}, so that by loosening the set-screw and swinging its handle one way or the other the resistance of the arm d^6 may be varied.

Preferably adjacent the periphery of the armature d^2 I place attracting means, herein shown in the form of solenoids or electromagnets d^{17} d^{18}, connected with the main or other source of current by wires d^{19}, which enter the solenoids at their inner terminals, so that as the magnets d^{17} d^{18} are energized they attract the armature or plate d^2, and by the increasing pull exerted thereon on account of the eccentric surfaces d^3 they cause the plate to rotate with a speed only checked by the striking of the interrupters d^4 against the end of the arm d^6, said rolls being placed relatively to the highest points of the surfaces d^3, so that they cut off the current just before said highest points get opposite the propelling-magnets, thereby permitting the momentum of the plate or armature d^2 to carry said highest points beyond the magnets sufficiently to prevent the latter exerting any retarding influence on the rotation of the break.

Preferably I mount the anvil and hammer on a swinging ledge or carrier d^{20}, journaled on the post d, so that I am enabled to regulate the speed of the break simply by swinging the carrier d^{20} one way or the other. The same effect may be obtained by shifting the

roll or rolls d^4 on the plate d^2, provided they are carried, as preferred, on a bar d^5, so that they can be shifted. This adjustment cannot of course take place while the apparatus is in operation, and therefore for instantaneous regulation of the apparatus I provide the swinging carrier d^{20}.

A movement of the carrier from right to left causes the current to be broken before the armature has reached its point of greatest attraction, and as it is moved farther toward the left the pull on the armature exerted by the magnets is diminished more and more, and the speed of rotation of the armature is correspondingly reduced, thereby reducing the number of breaks and at the same time lengthening the time which the circuit being interrupted is closed.

I place the arm or wire d^6 slightly tangential to the armature, as will be seen viewing Fig. 1, in order that the rolls d^4 may strike the extreme end thereof with least friction, striking outward instead of square against the end. The arm d^6 is connected to the main or branch therefrom at d^{21} by means of any suitable conductor d^{22}, and the anvil d^8 has a connection d^{23} to the delivery end d^{24} of the circuit, as will readily be understood.

In operation the magnets being energized attract the eccentric surfaces or other varying masses of magnetic material, so as to cause the armature to rotate over to the left, Fig. 1, the circuit being completed at d^7 d^8 until the very moment when the interrupter d^4 strikes the free end of the arm d^6, whereupon the circuit is instantaneously broken, and as this time occurs slightly before the highest points or places of greatest attraction of the armature come opposite the solenoids the latter are rendered inactive merely during the moment when the momentum of the armature is carrying the latter by the solenoids, so as to bring the region of least magnetic mass again opposite the solenoids in position for the latter, upon becoming active by the making again of the circuit, to renew their pull upon the armature, and thereby continue its rapid revolution. This action is rapidly repeated at every make and break of the instrument.

I prefer to provide opposite solenoids in order to render the device perfectly balanced and smooth-running, although it will be understood that variations in this and in all other details of my invention may be made.

By the use of my invention the time-period of closed circuit may be made as considerable as desired. With any usual break this would be impossible, for the reason that in order to give an equivalent period of closed circuit the brush would of necessity remain upon the surface of the break so long as to heat frictionally the surfaces, so as to produce a constant arc, ultimately destroying the break as well as the efficiency of the circuit. In my there is not even a spark at the time of break, but there is merely occasionally a residual spark upon the closing of the break.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. An electric break comprising a rotating member, an electromagnet, a break device, and means driven by said rotating member for interrupting said break device, said rotating member presenting a surface of attraction to said magnet eccentric to the center of rotation of said member, substantially as described.

2. An electric break comprising a rotating member, an electromagnet, a break device, and means driven by said rotating member for interrupting said break device, said rotating member presenting a surface of attraction to said magnet eccentric to the center of rotation of said member, and means for varying the time of interruption of said break device relatively to the point of highest attraction of said eccentric surface, substantially as described.

3. An electric break comprising a rotating member, an electromagnet, a spring, a break device, means to vary the resistance of said break device, and means driven by said rotating member for interrupting said break device, said rotating member presenting a surface of attraction to said magnet eccentric to the center of rotation of said member, and means for varying the time of interruption of said break device relatively to the point of highest attraction of said eccentric surface, substantially as described.

4. An electric break comprising a rotating member having regions of varying mass of magnetic material producing regions of increasing magnetic attraction, an electromagnet adjacent said rotating member, a break device, and an interrupter driven by said rotating member for interrupting the break device, substantially as described.

5. An electric break comprising a rotating member having regions of varying mass of magnetic material producing regions of increasing magnetic attraction, an electromagnet adjacent said rotating member, a break device, and an interrupter carried by said rotating member for interrupting the break device, substantially as described.

6. An electric break comprising a rotating member having regions of varying mass of magnetic material producing regions of increasing magnetic attraction, an electromagnet adjacent said rotating member, a break device, and a pivoted roll carried by said rotating member for interrupting the break device, substantially as described.

7. An electric break comprising a rotating member having regions of increasing magnetic attraction, an electromagnet adjacent

for adjusting said roll on said rotating member, substantially as described.

8. An electric break comprising a rotating member having regions of increasing magnetic attraction, an electromagnet adjacent said rotating member, a break device, and a bar fixed on said rotating member and provided with rolls pivoted thereon at its opposite ends in line with and to interrupt said break device, substantially as described.

9. An electric break comprising a rotating member having regions of increasing magnetic attraction, an electromagnet adjacent said rotating member, a break device, and an interrupter carried by said rotating member for interrupting the break device, said break device being mounted on a carrier movable concentrically to said rotating member, substantially as described.

10. An electric break comprising a rotating member having regions of increasing magnetic attraction, an electromagnet adjacent said rotating member, a break device, and a revolving interrupter driven by said rotating member, said break device including a yielding arm projecting obliquely into the path of said interrupter, substantially as described.

11. An electric break comprising an arm carrying a hammer, an anvil opposite said hammer, said arm being yieldingly supported and provided with means for regulating the tension or resistance thereof, an interrupter for engaging the free end of said arm, and automatic means operated by the current being broken for driving said interrupter, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THOMAS B. KINRAIDE.

Witnesses:
GEO. H. MAXWELL,
ALEXANDER C. PROUDFIT.

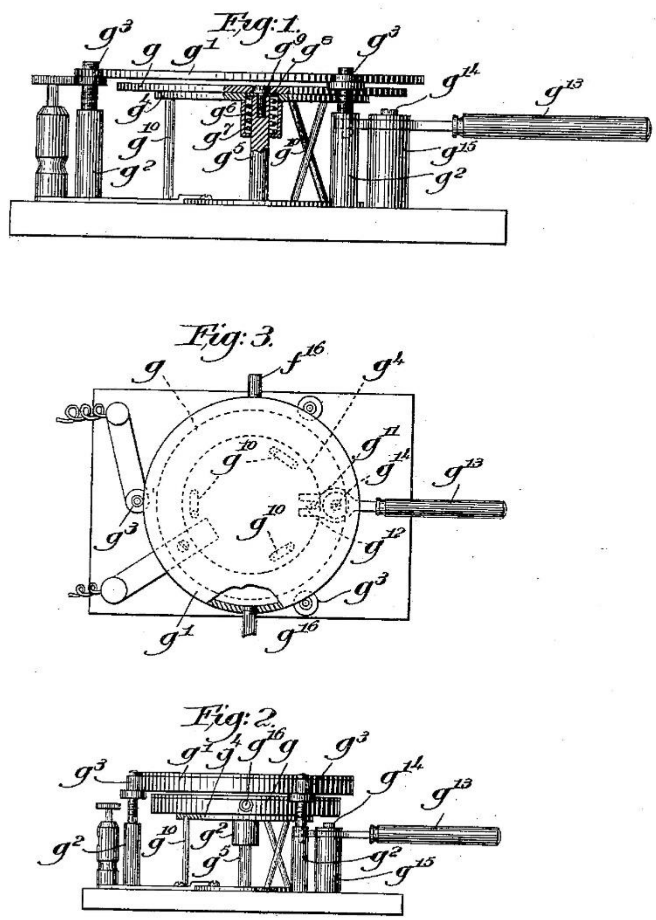
No. 623,318. Patented Apr. 18, 1899.

T. B. KINRAIDE.

ELECTRICAL SPARK GAP.

(Application filed Sept. 24, 1898.)

(No Model.)



Witnesses,
Edward F. Allen.
James M. Urquhart.

Inventor,
Thomas B. Kinraide
by Crosby Gregory
Att'ys.

UNITED STATES PATENT OFFICE.

THOMAS B. KINRAIDE, OF BOSTON, MASSACHUSETTS.

ELECTRICAL SPARK-GAP.

SPECIFICATION forming part of Letters Patent No. 623,318, dated April 18, 1899.

Application filed September 24, 1898. Serial No. 691,758. (No model.)

To all whom it may concern:

Be it known that I, THOMAS B. KINRAIDE, of Boston, county of Suffolk, State of Massachusetts, have invented an Improvement in Electric Spark-Gaps, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

The more recent developments in electrical matters, and particularly in the line of experimental research in connection with static electricity, have developed conditions requiring the discharge of such enormous potentials and amperage as to render the apparatus heretofore provided for such purposes inefficient and largely useless, for the reason that these enormous discharges which the electrician frequently desires to experiment or deal with very quickly render inoperative or destroy such usual apparatus.

Accordingly it is the object of my present invention to provide a practically indestructible discharge apparatus to meet the more exacting requirements of the present day; and to that end I provide a spark-gap which is virtually self-recuperative and comprises opposite parallel discharge-surfaces of considerable area, which, besides their practically indestructible character, possess numerous very important advantages, all as will be more fully pointed out in the course of the following detailed description of the apparatus, reference being had to the accompanying drawings, illustrative of preferred embodiments thereof.

In the drawings, Figure 1 represents in side elevation a simple form of my improved spark-gap. Fig. 2 is a similar view showing a modification. Fig. 3 is a top plan view of the form of apparatus shown in Fig. 2.

While the spark-gap which constitutes my invention and which I will now describe is primarily intended for use in discharging condensers, as shown in my application, Serial No. 679,799, filed May 5, 1898, it will be understood that it is not limited thereto, but may be employed in various other relations.

I provide electrodes preferably in the form of opposite parallel disks $g\ g'$, the air-gap between whose plane surfaces constitutes the spark-gap, the extended area of these electrodes preventing the tendency of the condenser, for example, to discharge until it has reached its maximum charge and also causing the discharge to be exceedingly sudden when it does take place and the disks not being liable to become unduly heated.

The spark-gap constitutes virtually a self-recuperative or indestructible condenser, as it were, the parallel and preferably plane metallic surfaces $g\ g'$ being the discharge-surfaces, which discharge through or across the intervening air dielectric. The air-gap is broken through when the voltage has exerted a sufficient strain upon the air to rupture it. The larger the disks are the greater condenser capacity will they have, and hence the farther apart they will spark.

At each discharge of the condenser a small portion of the plates $g\ g'$ is oxidized, the successive discharges producing very thin oxidation here and there until the entire surfaces of the two disks are completely oxidized. Suitable means is provided for accurately adjusting these plates relatively to each other and regulating their distance apart, or, in other words, for controlling the resistance of the intervening gaseous dielectric, and, referring to the drawings, where I have shown a preferred means for accomplishing my object, it will be seen that I provide a plurality of posts g^2, threaded at their upper ends and carrying shouldered nuts g^3, on the shoulders of which is placed the top disk g'. The opposite plate g rests on a support or table g^4 and is mounted loosely on a post g^5, being normally held downwardly by a spring g^6, contained in a hanger or housing g^7, depending from the table g^4, said spring bearing at one end against the flanged lower end of the hanger g^7 and at its other end bearing against a washer g^8, retained by a screw g^9, whose head enters a hole or recess in the plate g for centering the latter.

The plate g is provided on its under side with a plurality of recesses or sockets, herein shown as three in number, which receive props or struts g^{10}, projecting upwardly from the base of the instrument. These props g^{10} are of precisely equal length, so that they support the plate g in absolute parallelism to its opposite plate g'. The support g^4 has depending from its lower side a stud g^{11}, which is engaged by the bifurcated end g^{12} of a lever g^{13}, pivoted at g^{14} to a post g^{15} on the base.

By this provision the most delicate adjustment is possible simply by swinging the lever g^{13} one way or the other, so as to incline the struts g^{10} more or less, and thereby increase or decrease the distance between the plates $g\ g'$, the nuts g^3 being depended upon for the coarser adjustments of the plates.

In Figs. 2 and 3 I have shown the plates g g' as hollow and provided with water-circulation pipes g^{16} in order that they may be absolutely prevented from all heating under extraordinary conditions. Under usual conditions, however, this provision is entirely unnecessary, it being sufficient simply to provide the plates, as shown in Fig. 1.

When the adjacent surfaces of the plates have become entirely oxidized, the plates may be turned over and their opposite sides used, and when both sides have become oxidized they may be readily removed and scoured off without destroying any of their adjustments.

My apparatus makes possible the sudden discharge of a condenser after the latter has reached a certain predetermined point, and said discharge is of great volume or large amperage and of a very sudden and abrupt nature, as the current will not break across the spark-gap until it cannot help doing so, and when it does do so the discharge takes place with a minimum heating effect, not interfering with the efficiency, with very rapid and with very short and sharp oscillations incapable of being obtained between a ball or point discharge gap.

The adjustment of the plates relatively to each other regulates the amperage-discharge of the instrument being discharged.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. A spark-gap of the kind described for use in a condenser-circuit, said spark-gap presenting opposite parallel discharge-surfaces of relatively large areas and means for regulating the discharge distance between said parallel surfaces, whereby a condenser charge may be automatically governed, substantially as described.

2. The herein-described spark-gap comprising opposite electrodes presenting parallel discharge-surfaces, one of said electrodes being supported on three or more struts of equal length, and means for rotating said strut-supported electrode about its center, whereby its adjustment may be varied to and from the opposite electrode, substantially as described.

3. A spark-gap, comprising two permanent large superficial areas parallel to each other, constituting opposite discharge-surfaces, and an interposed gaseous dielectric, said discharge-surfaces having condenser capacity for breaking down the intervening dielectric, and the latter automatically restoring or renewing itself, substantially as described.

4. A spark-gap comprising opposite hollow plates or disks having parallel discharge-surfaces, means for regulating the discharge distance between said surfaces, and circulation-pipes entering the same, whereby a circulation of water may be maintained for keeping the plates or disks cool, substantially as described.

5. A spark-gap comprising three or more posts, shoulders adjustable thereon, a plate or disk supported on said shoulders, a second plate below the same, a support therefor, three or more upright struts loosely engaging said support, and means to rotate said support about its center, whereby said struts are simultaneously and similarly moved for varying the distance apart of said plates, substantially as described.

6. A spark-gap comprising a central post, a plurality of supporting-posts, two plates, one carried by said supporting-posts and the other adjacent said central post, three or more similar struts supporting said lower plate, a spring maintaining said struts in proper supporting relation, and means to rotate the lower plate on said central post, substantially as described.

7. A spark-gap comprising a plurality of supporting-posts, two plates, the lower plate being pivotally mounted, three or more similar struts supporting said lower plate, and the upper plate being supported by said supporting-posts, a lever pivotally mounted adjacent said lower plate and loosely connected therewith at its inner end for rotating said plate and tipping said struts, substantially as described.

8. A spark-gap comprising a central post, a plurality of supporting-posts, two plates, the lower plate being pivotally mounted concentrically to said central post, a hanger depending adjacent said post, a spring between said post and hanger and engaging the hanger at its lower end and held by the post at its upper end, three or more similar struts supporting said lower plate, and the upper plate being supported by said supporting-posts, a lever pivotally mounted adjacent said lower plate and loosely connected therewith at its inner end for rotating said plate and tipping said struts, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THOMAS B. KINRAIDE.

Witnesses:
GEO. H. MAXWELL,
ALEXANDER C. PROUDFIT.

3

N° 5518 A.D. 1899

Date of Application, 14th Mar., 1899—Accepted, 8th July, 1899

COMPLETE SPECIFICATION.

Improvements in Electric Spark Gap Apparatus.

I, Thomas Burton Kinraide, of 38, Spring Park Avenue, Jamaica Plain, in the State of Massachusetts, one of the United States of America, Electrician, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The more recent developments in electrical matters, and particularly in the line of experimental research in connection with static electricity, has developed conditions requiring the discharge of such enormous potentials and amperage as to render the apparatus heretofore provided for such purposes inefficient and largely useless, for the reason that these enormous discharges which the electrician frequently desires to experiment or deal with very quickly render inoperative or destroy such usual apparatus.

Accordingly, it is the object of my present invention to provide a practically indestructible discharge apparatus to meet the more exacting requirements of the present day, and to that end I provide a spark gap which is virtually self-recuperative, and comprises opposite parallel discharge surfaces of considerable area, which, besides their practically indestructible character, possess numerous very important advantages all as will be more fully pointed out in the course of the following detailed description of the apparatus, reference being had to the accompanying drawings illustrative of preferred embodiments thereof.

In the drawings, Fig. 1 represents in side elevation a simple form of my improved spark gap.

Fig. 2 is a similar view shewing a modification.

Fig. 3 is a top plan view of the form of apparatus shewn in Fig. 2.

I provide electrodes preferably in the form of opposite parallel discs g, g^1, the air gap between whose frame surfaces constitutes the spark gap, the extended area of these electrodes preventing the tendency of the condenser (for example) with which my invention will ordinarily be used, to discharge until it has reached its maximum charge, and also causing the discharge to be exceedingly sudden when it does take place, and the discs not being liable to become unduly heated.

The spark gap constitutes virtually a self-recuperative condenser, as it were, the parallel, and preferably plane, metallic surfaces g, g^1, being the discharge surfaces which discharge through or across the intervening air dielectric. The air gap is broken through when the voltage has exerted a sufficient strain upon the air to rupture it. The larger the discs are, the greater condenser capacity will they have, and hence the further apart they will spark.

At each discharge of the condenser a small portion of the plates g, g^1, is oxidized, the successive discharges producing very thin oxidation here and there until the entire surfaces of the two discs are completely oxidised. These discs may be made of copper or other suitable conductor material.

Suitable means is provided for accurately adjusting these plates relatively to each other and regulating their distance apart, or, in other words, for controlling the resistance of the intervening gaseous dielectric, and referring to the drawings, where

[*Price* 8*d.*]

I have shewn a preferred means for accomplishing my object, it will be seen that I provide a plurality of posts g^2 threaded at their upper ends and carrying shouldered nuts g^3 on the shoulders of which is placed the top disc g^1.

The opposite plate g rests on a support or table g^4 and is mounted loosely on a post g^5, being normally held downwardly by a spring g^6 contained in a hanger or housing g^7 depending from the table g^4 said spring bearing at one end against the flanged lower end of the hanger g^7 and at its other end bearing against a washer g^8 retained by a screw g^9 whose head enters a hole or recess in the plate g for centering the latter.

The plate g is provided on its underside with a plurality of recesses or sockets, herein shewn as three in number, which receive props or struts g^{10} projecting upwardly from the base of the instrument.

These props g^{10} are of precisely equal length, so that they support the plate g in absolute parallelism to its opposite plate g^1.

The support g^4 has depending from its lower side a stud g^{11} which is engaged by the bifurcated end g^{12} of a lever g^{13} pivoted at g^{14} to a post g^{15} on its base.

By this provision the most delicate adjustment is possible simply by swinging the lever g^{13} one way or the other so as to incline the struts g^{10} more or less, and thereby increase or decrease the distance between the plates g, g^1, the nuts g^3 being depended upon for the coarser adjustments of the plates.

In Figs. 2 and 3 I have shewn the plates g, g^1, as hollow and provided with water circulation pipes g^{16}, in order that they may be absolutely prevented from all heating under extraordinary conditions.

Under usual conditions, however, this provision is entirely unnecessary, it being sufficient simply to provide the plates as shewn in Fig. 1.

When the adjacent surfaces of the plates have become entirely oxidized, the plates may be turned over and their opposite sides used, and when both sides have become oxidized, they may be readily removed and scoured off without destroying any of their adjustments.

My apparatus makes possible the sudden discharge of a condenser after the latter has reached a certain predetermined point, and said discharge is of great volume or large amperage and of a very sudden and abrupt nature, as the current will not break across the spark gap until it cannot help doing so, and when it does do so the discharge takes place with a minimum heating effect, not interfering with the efficiency, with very rapid and with very short and sharp oscillations incapable of being obtained between a ball or point discharge gap.

The adjustment of the plates relatively to each other regulates the amperage discharge of the instrument being discharged.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. A spark gap of the kind described, said spark gap presenting opposite parallel discharge surfaces of relatively large areas, and means for regulating the discharge distance between said parallel surfaces, substantially as described.

2. The herein described spark gap comprising opposite electrodes presenting parallel discharge surfaces, one of said electrodes being supported on three or more struts of equal length, and means for rotating said strut-supported electrode about its centre, whereby its adjustment may be varied to and from the opposite electrode, substantially as described.

3. A spark gap comprising two permanent large superficial areas parallel to each other, constituting opposite discharge surfaces, and an interposed gaseous dielectric, said discharge surfaces having condenser capacity for breaking down the intervening dielectric, and the latter automatically restoring or renewing itself, substantially as described.

4. A spark gap comprising opposite hollow plates or discs having parallel discharge surfaces, means for regulating the discharge distance between said surfaces, and

circulation pipes entering the same, whereby a circulation of water may be maintained for keeping the plates or discs cool, substantially as described.

5. A spark gap comprising three or more posts, shoulders adjustable thereon, a plate or disc supported on said shoulders, a second plate below the same, a support therefor, three or more upright struts loosely engaging said support, and means to rotate said support about its centre, whereby said struts are simultaneously and similarly moved for varying the distance apart of said plates, substantially as described.

6. A spark gap comprising a central post, a plurality of supporting posts, two plates, one carried by said supporting posts and the other adjacent said central post, three or more similar struts supporting said lower plate, a spring maintaining said struts in proper supporting relation, and means to rotate the lower plate on said central post, substantially as described.

7. A spark gap comprising a plurality of supporting posts, two plates, the lower plate being pivotally mounted, three or more similar struts supporting said lower plate, and the upper plate being supported by said supporting posts, a lever pivotally mounted adjacent said lower plate and loosely connected therewith at its inner end for rotating said plate and tipping said struts, substantially as described.

8. A spark gap comprising a central post, a plurality of supporting posts, two plates, the lower plate being pivotally mounted concentrically to said central post, a hanger depending adjacent said post, a spring between said post and hanger and engaging the hanging at its lower end and held by the post at its upper end, three or more similar struts supporting said lower plate, and the upper plate being supported by said supporting posts, a lever pivotally mounted adjacent said lower plate and loosely connected therewith at its inner end for rotating said plate and tipping said struts, substantially as described.

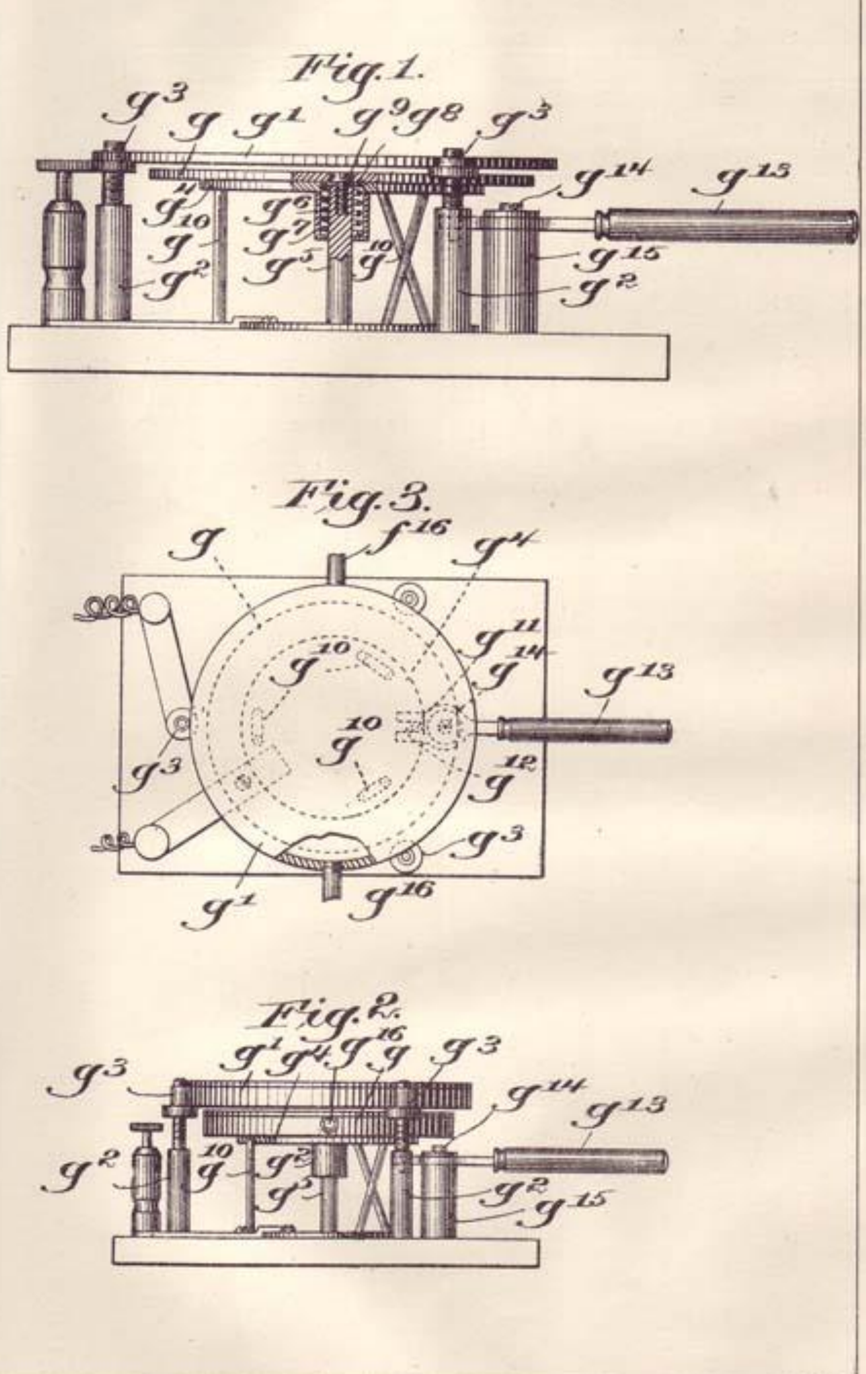
Dated the 14th day of March 1899.

WM. BROOKES & SON,
55 and 56, Chancery Lane, London, Agents for the Applicant.

Redhill: Printed for Her Majesty's Stationery Office, by Malcomson & Co., Ltd.—1899.

A.D. 1899. March 14. N° 5518.
KINRAIDE'S Complete Specification.

(1 SHEET)



[This Drawing is a reproduction of the Original on a reduced scale.]

Malby & Sons, Photo-Litho.

Eigenthum
des Kaiserlichen
Patentamts.

KAISERLICHES PATENTAMT.

AUSGEGEBEN DEN 2. MÄRZ 1900.

PATENTSCHRIFT

— № 108924 —
a. Gruppe 6/5

KLASSE 21: Elektrische Apparate und Maschinen.

THOMAS BURTON KINRAIDE in JAMAICA-PLAIN (Mass., V. St. A.).

Vorrichtung zur Erzeugung elektrischer Entladungen.

Patentirt im Deutschen Reiche vom 21. März 1899 ab.

Die neuerliche Entwickelung auf elektrischem Gebiet, insbesondere in Richtung der experimentellen Arbeit mit statischer Elektricität erfordert Entladungen von solch enormem Potential bezw. Mengen aufgespeicherter Elektricität, dafs die üblichen Vorrichtungen, indem sie sehr rasch unwirksam werden oder der Zerstörung unterliegen, unzureichend geworden sind.

Dieser Uebelstand wird der vorliegenden Erfindung gemäfs beseitigt durch die Verwendung des bekannten Kohlrausch'schen Plattencondensators als Funkengeber zur Erzeugung oscillirender Entladungen, d. h. es wird die Entladung bewirkt vermittelst zweier unter Belassung eines Funkenraumes streng parallel zu einander angeordneten Flächen von grofser Ausdehnung.

Die Erfindung ist in zwei Beispielen in den beiliegenden Zeichnungen veranschaulicht.

Fig. 1 zeigt in Seitenansicht eine sehr einfache Ausführungsform und

Fig. 2 in gleicher Darstellung eine mit Kühlvorrichtung für die Entladungsplatten versehene Abänderung; Fig. 3 ist die Oberansicht zu Fig. 2.

Die Entladungselektroden bestehen aus den metallenen Platten oder Scheiben $g\,g^1$, welche, mit möglichst ebener Oberfläche versehen, streng parallel zu einander angeordnet sind; der Luftraum zwischen den Platten bildet den Funkenraum. Je gröfser die Scheiben sind, um so gröfsere Condensatorcapacität besitzen sie, und durch einen um so weiteren Zwischenraum lassen sie Funken überschlagen.

Die Scheiben bezw. Platten $g\,g^1$ sind behufs Aenderung des Widerstandes des zwischengeschalteten gasförmigen Dielektrikums verstellbar gemacht. Aus den Zeichnungen, in denen die hierzu vom Erfinder angewendete Einrichtung veranschaulicht ist, ersieht man, dafs eine Anzahl Säulen g^2 angeordnet ist, auf deren obere mit Gewinde versehene Enden Muttern g^3 geschraubt sind mit Schultern zum Aufsetzen der oberen Scheibe oder Platte g^1.

Die Gegenscheibe g ruht auf einer Unterlage oder einem Tisch g^4; sie ist lose in einem Säulchen g^5 gehalten und wird für gewöhnlich gegen ihre Unterlage gezogen durch eine Schraubenfeder g^6, welche in einem von der Unterlage herabhängenden Gehäuse g^7 angeordnet ist. Diese Feder g^6 stützt sich mit dem unteren Ende gegen den Boden des Gehäuses und mit dem oberen Ende gegen eine Scheibe g^8, welche durch eine Schraube g^9 festgehalten ist, deren Kopf in der Scheibe g zur Centrirung derselben versenkt ist. Die Scheibe g ist auf der Unterseite mit einer Anzahl, auf der Zeichnung z. B. drei, Vertiefungen versehen zur Aufnahme der oberen Enden von Stützen g^{10}. Letztere sind von genau gleicher Länge, so dafs sie die Scheibe g absolut parallel zur Gegenscheibe g^1 halten. Von der Unterseite der Unterlage g^4 ragt nach unten ein Zapfen g^{11} (Fig. 3), welchen das gegabelte Ende g^{12} eines Hebels g^{13} umfafst, der in g^{14} drehbar auf einer Säule g^{15} gelagert ist. Infolge dieser Einrichtung ist die genaueste Einstellung in einfacher Weise ermöglicht, indem man durch Drehen des Hebels (nach der einen oder anderen Seite) den Stützen g^{10} eine gröfsere oder geringere Neigung ertheilen und

dadurch den Abstand zwischen den Scheiben $g\, g^1$ entsprechend vergröfsern und verringern kann. Die Muttern g^3 dienen gröberer Einstellung durch Heben oder Senken der oberen Scheibe.

In den Fig. 2 und 3 sind hohle Scheiben $g\, g^1$ in Verbindung mit Wassercirculationsröhren g^{16} gezeigt, um jeder Erwärmung unter aufsergewöhnlichen Umständen begegnen zu können. Für gewöhnliche Umstände ist diese Vorkehrung völlig überflüssig.

Sind die Scheiben auf den Entladungsflächen vollständig oxydirt, so kann man sie umwenden und die Kehrseiten als Entladungsflächen benutzen. Sind auch diese oxydirt, so kann man die Scheiben leicht herausnehmen und blank machen, ohne eine ihrer Einstellungen zu zerstören.

Die Erfindung ermöglicht unter Entwickelung von nur wenig Wärme die jähe Entladung eines Condensators bei Erreichung einer bestimmten Ladung unter Erzeugung von Oscillationen, wie sie mit gleicher Rapidität, Kürze und Schärfe vermittelst der Entladung zwischen Kugel und Spitze nicht erzielbar sind.

Patent-Ansprüche:

1. Eine Vorrichtung zur Erzeugung elektrischer Entladungen, gekennzeichnet durch die Verwendung des Kohlrausch'schen Plattencondensators als Funkengeber.
2. Eine Ausführungsform der unter 1. geschützten Vorrichtung, bei welcher eine der Entladungsoberflächen von drei oder mehr Stützen von gleicher Länge getragen wird, welche so angeordnet sind, dafs sie zur Regelung des gegenseitigen Abstandes der Entladungsflächen zusammen geneigt werden können.
3. Eine Ausführungsform der unter 1. geschützten Vorrichtung, bei welcher die Entladungsoberflächen mit Circulationsvorrichtung behufs Durchleitung von Kühlwasser versehen sind.

Hierzu 1 Blatt Zeichnungen.

BERLIN. GEDRUCKT IN DER REICHSDRUCKEREI.

THOMAS BURTON KINRAIDE in JAMAICA-PLAIN (Mass., V. St. A.).

Vorrichtung zur Erzeugung elektrischer Entladungen.

Fig. 1.

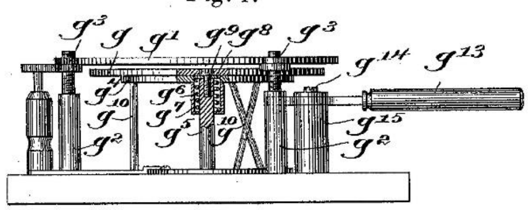


Fig. 3.

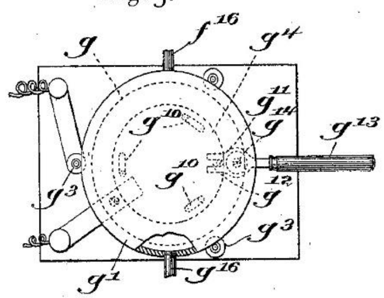
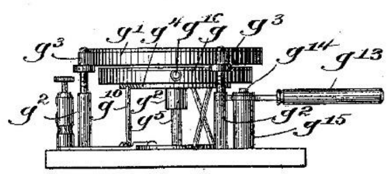


Fig. 2.



Zu der Patentschrift

№ 108924.

PHOTOGR. DRUCK DER REICHSDRUCKEREI.

KAISERLICHES PATENTAMT.

AUSGEGEBEN DEN 10. DEZEMBER 1900.

PATENTSCHRIFT

— № 115738 —

KLASSE 21g.

THOMAS BURTON KINRAIDE IN JAMAICA-PLAIN (MASS., V. ST. A.).

Elektrischer Selbstunterbrecher.

Patentirt im Deutschen Reiche vom 21. März 1899 ab.

Die vorliegende Erfindung bezieht sich auf Stromunterbrecher, welche nach Art der in Thompson, Der Elektromagnet, 1894, auf Seite 251 (Fig. 133) und Seite 265 (Fig. 150) beschriebenen Motoren gebaut sind, d. h. in der Art, dafs ein die Stromöffnung veranlassendes Glied an einem mit Regionen von zunehmender und dann jäh absetzender Masse magnetischen Materials versehenen rotirenden Elektromagnetanker, und zwar so angeordnet ist, dafs es den Elektromagnetstromkreis öffnet, kurz bevor der Anker mit den Punkten gröfster magnetischer Masse vor den oder die Elektromagnete gekommen ist, so dafs der Anker sich unter seiner lebendigen Kraft weiter dreht und so die Wiederherstellung des Stromschlusses veranlafst. Die Erfindung bezweckt die leichte Veränderbarkeit der Unterbrechungszahl bezw. Periodenlänge; dies wird dadurch erreicht, dafs der daumenscheibenförmig gestaltete Anker durch ein um seine Achse verstellbares Glied abhebend gegen einen in seiner Spannung durch Torsionsfederlagerung regelbaren Hammer wirkt, der zusammen mit dem Ambos auf einem um die Ankerachse verstellbaren Träger angeordnet ist. Es kann so vermittelst Verstellung des Abhebegliedes vor dem Gebrauch des Apparates die Periodenlänge eingestellt, und diese dann dem während der Thätigkeit des Apparates hervortretenden Bedürfnifs entsprechend verlängert oder verkürzt werden, indem man den genannten Träger so dreht, dafs er den Hammer in der Bahn des genannten Gliedes weiter vorwärts- oder zurückstellt.

Der Unterbrecher ist auf der beiliegenden Zeichnung in einem Ausführungsbeispiel dargestellt, welches Fig. 1 in der Oberansicht und Fig. 2 in einer Seitenansicht zeigt.

Die in der Lagerhülse d drehbare, stehende Spindel d^1 trägt eine Ankerscheibe d^2 von solcher Form, dafs sie dem oder den (z. B. zwei) einander diametral gegenüber angeordneten Elektromagneten oder Solenoiden d^{17} d^{18} Regionen von zunehmender magnetischer Masse darbietet, indem ihre Peripherie z. B. zu zwei excentrisch verlaufenden und dann jäh abfallenden hubdaumenartigen Vorsprüngen d^3 ausgebildet ist. Für jede Umdrehung des Ankers wächst so seine Geschwindigkeit von einer gleichen Anfangsgeschwindigkeit bis zu einem gleichen Maximum. Mit dem Anker d^2 rotiren Antifrictionsröllchen d^4, deren die Zeichnung z. B. zwei an den entgegengesetzten Enden einer auf dem Anker befestigten Schiene d^5 angeordnet zeigt. Sie werden vorzugsweise aus Vulkanit oder anderem geeigneten Isolirmaterial hergestellt. In ihren Weg ragt ein, z. B. aus einem Drahtstück bestehender Arm d^6, der den Hammer d^7 zum Stromschliefsen mit dem Ambos d^8 trägt, welcher auf dem Ende einer Einstellschraube d^9 sitzt. Ein vermittelst Schraube d^{11} verstellbarer Anschlag d^{10} (aus gehärteter Faser) be-

grenzt die Hammerbahn auf der entgegengesetzten Seite. Der Arm oder Stiel d^6 sitzt vermittelst Nabe d^{12} lose auf einem Zapfen d^{13} und wird federnd gestützt durch eine Schraubenfeder d^{14} (Fig. 2), die am einen Ende mit der Nabe d^{12} und am anderen Ende mit einem Ring d^{15} zusammenhängt, welcher mittelst Klemmschraube d^{16} auf dem Zapfen d^{13} festgeklemmt werden kann. Durch Verdrehen des Ringes nach Lösen der Schraube läfst sich somit die Hammerspannung einstellen.

Auf der Zeichnung ist angenommen, der Unterbrecher vermittele das Laden eines Condensators; letzterer ist vermittelst Leitungen $d^{21} d^{24}$ und Klemmen $D^1 D^2$ über die Elektromagnete $d^{17} d^{18}$ an die Stromquelle, und der Unterbrecher ist zwischen die Elektromagnete gelegt. Gesetzt, der Unterbrecher schliefse sich (d^7 auf d^8); alsdann ist der Condensator kurz geschlossen und derselbe entladet sich infolge dessen. Der Stromkreis der Elektromagnete jedoch ist geschlossen, und es fliefst der Strom: Stromquelle, $d^{19}, d^{18}, D^1, d^{22}, d^7, d^8, d^{23}, D^2, d^{17}, d^{19}$, Stromquelle. Die Elektromagnete erhalten also Strom und ertheilen dem Anker d^2 Drehung nach links (Pfeil Fig. 1), und zwar wegen des excentrischen Verlaufes der Vorsprünge d^3 mit wachsender Geschwindigkeit, so dafs das in der Drehrichtung vordere Röllchen d^4 mit Kraft gegen das Ende des Hammerstieles stöfst, und der Schlufs $d^7 d^8$ augenblicklich geöffnet wird. Die Röllchen d^4 sind bezüglich der Ankervorsprünge d^3 so gelegt, dafs sie den Hammer früher aus der Berührung mit dem Ambos stofsen, als die äufsersten Theile von d^3, das sind die Punkte stärkster Anziehung, den Elektromagneten gegenüber kommen; der Anker hat also im Moment der Stromöffnung bezw. des Stromloswerdens der Elektromagnete eine sehr hohe lebendige Kraft. Hierdurch wird der Stromkreis der Elektromagnete unterbrochen und der Kurzschlufs des Condensators aufgehoben. Es fliefst alsdann der Strom von der Stromquelle d^{19}, Elektromagnet d^{18}, Klemme $D^1 d^{21}$, Condensator $d^{24} D^2$, Elektromagnet d^{17} zum negativen Pol der Stromquelle, und der Condensator ladet sich. Da der Ladestrom jedoch sehr schwach ist, so werden die Elektromagnete $d^{17} d^{18}$ durch ihn nicht merklich erregt und können als stromlos angesehen werden. Unterdessen hat sich die Ankerscheibe d^2 mit den Armen d^5 und den Röllchen d^4 vermöge der lebendigen Kraft weiter gedreht, die Punkte stärkster Anziehung sind an den Elektromagneten vorbeigegangen und die Punkte schwächster Anziehung vor dieselben gekommen; nun läfst das Röllchen d^4 den Hammer $d^6 d^7$ los und vermöge der Feder d^{14} wird der Hammer d^7 gegen d^8 gedrückt und der Schlufs $d^7 d^8$ wieder hergestellt. Alsdann wiederholt sich derselbe Vorgang. Der Stiel d^6 wird zweckentsprechend tangential zum Anker gestellt, damit die Röllchen d^4 möglichst wenig Reibung zu überwinden haben.

Die Röllchenschiene d^4 ist auf der Ankerachse verstellbar angeklemmt; andererseits sind Ambos und Hammer auf einem Träger d^{20} angeordnet, der um die Lagerhülse d (der Spindel d^1) als Zapfen drehbar ist. Hierdurch ist einerseits die Einstellung der Periodenlänge vor der Inbetriebsetzung des Apparates, andererseits die Aenderung der Periode während des Betriebes auf einfachste Weise ermöglicht; je mehr man die Röllchen d^4 in Bezug auf die Ankerscheibe d^2 in der Drehrichtung derselben verstellt, um so gröfser wird der Abstand der Punkte stärkster Anziehung zwischen den Vorsprüngen d^3 und den Elektromagneten im Zeitpunkte des Oeffnens; letztere üben also auch nur eine schwächere Anziehung auf den Anker aus, und dessen Drehgeschwindigkeit findet sich entsprechend verlangsamt, so dafs die Anzahl der Unterbrechungen pro Zeiteinheit vermindert, d. h. die Dauer des jeweiligen Stromschlusses bezw. des Condensatorkurzschlusses verlängert wird und umgekehrt. Dreht man nun den Träger d^{20} z. B. nach rechts, so wird der Abstand zwischen Hammer und rechtsseitigem Elektromagnet verkürzt und entsprechend auch im Oeffnungsaugenblick der Abstand zwischen den Punkten stärkster Anziehung der Vorsprünge d^3 und den Elektromagneten verringert; letztere üben also eine stärkere Anziehung aus und beschleunigen entsprechend die Ankerdrehung, und umgekehrt.

Infolge der beschriebenen Einrichtung kann die Stromschlufsperiode für die Elektromagnete so beträchtlich wie gewünscht bemessen werden. Mit einem gewöhnlichen Unterbrecher würde dies unmöglich sein, weil die Bürste während der Schlufsperiode aufliegen bleiben müfste und die beschliffene Fläche durch ihre Reibung so stark erhitzen würde, dafs eine constante Bogenbildung stattfände, welche nicht nur die Wirksamkeit des Stromkreises schädigen, sondern schliefslich auch den Apparat zerstören würde. Im beschriebenen Unterbrecher ist nicht nur keine Gelegenheit zur Bogenbildung vorhanden, weil die dazu erforderliche Oberfläche überhaupt fehlt, sondern es vollzieht sich auch die Oeffnung so ungemein rasch, dafs sie nicht einmal einen Funken überspringen macht, was nur gelegentlich beim Schlufsmachen eintritt.

Patent-Anspruch:

Elektrischer Selbstunterbrecher, bei welchem die mit Stellen von zunehmender und dann

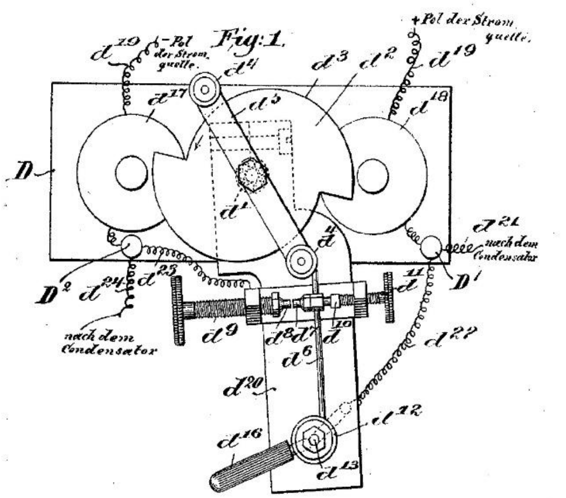
jäh absetzender Masse magnetischen Stoffes versehene umlaufende Ankerscheibe eines oder mehrerer Elektromagnete einen Hammer abhebt und dadurch den Stromkreis öffnet, dadurch gekennzeichnet, dafs der in seiner Spannung durch Torsionsfederlagerung (d^{14}) regelbare Hammer (d^7) zusammen mit dem Ambos (d^8) auf einem um die Achse der Ankerscheibe (d^2) drehbaren Träger (d^{20}) angeordnet und das von der Ankerscheibe mitgedrehte Oeffnungsglied (d^4) um genannte Achse verstellbar ist.

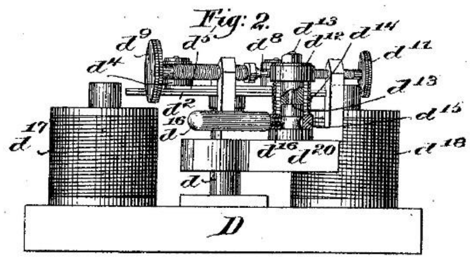
Hierzu 1 Blatt Zeichnungen.

BERLIN. GEDRUCKT IN DER REICHSDRUCKEREI.

THOMAS BURTON KINRAIDE IN JAMAICA-PLAIN (MASS., V. ST. A.).

Elektrischer Selbstunterbrecher.





Zu der Patentschrift

№ 115738.

PHOTOGR. DRUCK DER REICHSDRUCKEREI.

July 22, 1901
Monday Morning

Mr. Gilder,
Editor Century Magazine, -
New York City.

My dear Mr Gilder,

Mr. Thomas B. Kinraide of Jamaica Plain has in the course of extended experiments, secured some very remarkable and valuable photographic plates containing records of electrical discharges. There are entirely different from any plates of the kind heretofore secured. They show several things that no other photographs of electricity have ever shown. Prof. Cross of the Massachusetts Institute of Technology will be glad to assure you of their scientific value should you care to correspond with him on the subject.

I may add that the Institute has recently accepted from Mr. Kinraide a set of about 50 plates.

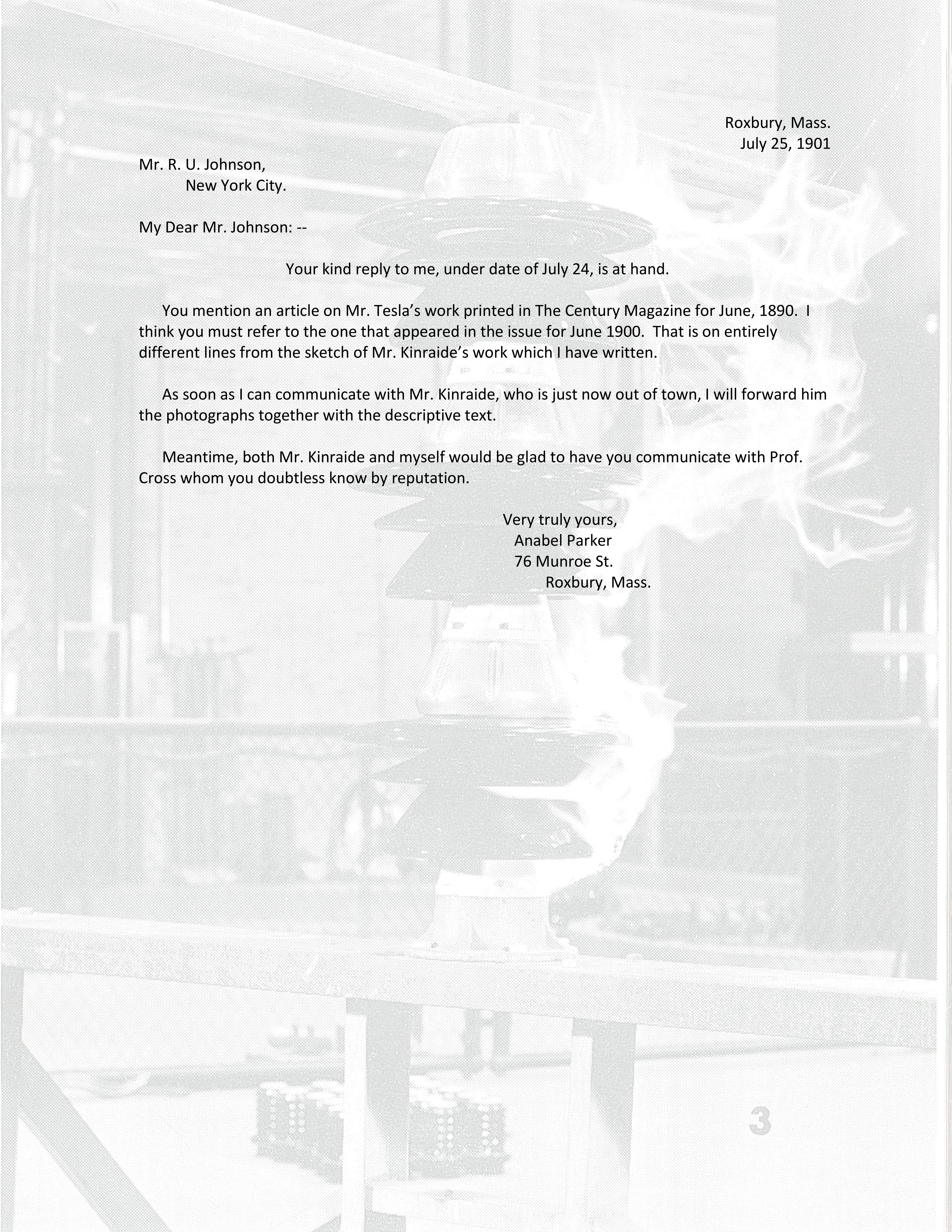
I have thought you might like to reproduce some of these plates – Mr. Kinraide calls them as “electrographs” – in the “Century”. Mr. Kinraide has selected a small number and has kindly allowed me to write a descriptive text explaining their meaning and the conditions under which the different ones were secured.

I think you might be interested to visit Mr. Kinraide’s laboratory and to see for yourself what he has done in this and other lines of electrical investigation. Should you care to do this, Mr. Kinraide will be glad to welcome you to meet Prof. Cross there.

You would then be able to satisfy yourself as to the scientific value of these electrographs and to judge whether or not an article in regard to them would be desirable for the “Century”.

Trusting you will find it agreeable to investigate Mr. Kinraide’s work,
I am,
Very truly yours,
(Miss) Anabel Parker
76 Munroe St.
Roxbury, Mass.

Mr. Kinraide’s address is
Thomas B. Kinraide, Esq.
Spring Park Ave.
Jamaica Plain,
Mass.



Roxbury, Mass.
July 25, 1901

Mr. R. U. Johnson,
New York City.

My Dear Mr. Johnson: --

Your kind reply to me, under date of July 24, is at hand.

You mention an article on Mr. Tesla's work printed in The Century Magazine for June, 1890. I think you must refer to the one that appeared in the issue for June 1900. That is on entirely different lines from the sketch of Mr. Kinraide's work which I have written.

As soon as I can communicate with Mr. Kinraide, who is just now out of town, I will forward him the photographs together with the descriptive text.

Meantime, both Mr. Kinraide and myself would be glad to have you communicate with Prof. Cross whom you doubtless know by reputation.

Very truly yours,
Anabel Parker
76 Munroe St.
Roxbury, Mass.

Recent Discoveries by Nikola Tesla.

VOL. LX, No. 2. JUNE PRICE, 35 CENTS.

THE CENTURY ILLUSTRATED MONTHLY MAGAZINE

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THE PROBLEM OF INCREASING HUMAN ENERGY.

WITH SPECIAL REFERENCE TO THE HARNESSING OF THE SUN'S ENERGY.

BY NIKOLA TESLA.

ILLUSTRATED BY THE WRITER'S ELECTRICAL EXPERIMENTS, NOW FIRST PUBLISHED.

THE ONWARD MOVEMENT OF MAN—THE ENERGY OF THE MOVEMENT—THE THREE WAYS OF INCREASING HUMAN ENERGY.

OF all the endless variety of phenomena which nature presents to our senses, there is none that fills our minds with greater wonder than that inconceivably complex movement which, in its entirety, we designate as human life. Its mysterious origin is veiled in the forever impenetrable mist of the past, its character is rendered incomprehensible by its infinite intricacy, and its destination is hidden in the unfathomable depths of the future. Whence does it come? What is it? Whither does it tend? are the great questions which the sages of all times have endeavored to answer.

Modern science says: The sun is the past, the earth is the present, the moon is the future. From an incandescent mass we have originated, and into a frozen mass we shall turn. Merciless is the law of nature, and rapidly and irresistibly we are drawn to our doom. Lord Kelvin, in his profound meditations, allows us only a short span of life, something like six million years, after which time the sun's bright light will have ceased to shine, and its life-giving heat will have ebbed away, and our own earth will be a lump of ice, hurrying on through the eternal night. But do not let us despair. There will still be left on it a glimmering spark of life, and there will be a chance to kindle a new fire on some distant star. This wonderful possibility seems, indeed, to exist, judging from Professor Dewar's beautiful experiments with liquid air, which show that germs of organic life are not destroyed by cold, no matter how intense; consequently they may be transmitted through the interstellar space. Meanwhile the cheering lights of science and art, ever increasing in intensity, illuminate our path, and the marvels they disclose, and the enjoyments they offer, make us measurably forgetful of the gloomy future.

Though we may never be able to comprehend human life, we know certainly that it is a movement, of whatever nature it be. The existence of a movement unavoidably implies a body which is being moved and a force which is moving it. Hence, wherever there is life, there is a mass moved by a force. All mass possesses inertia, all force tends to persist. Owing to this universal property and condition, a body, be it at rest or in motion, tends to remain in the same state, and a force, manifesting itself anywhere and through whatever cause, produces an equivalent opposing force, and as an absolute necessity of this it follows that every movement in nature must be rhythmical. Long ago this simple truth was clearly pointed out by Herbert Spencer, who arrived at it through a somewhat different process of reasoning. It is borne out in everything we perceive—in the movement of a planet, in the surging and ebbing of the tide, in the reverberations of the air, the swinging of a pendulum, the oscillations of an electric current, and in the infinitely varied phenomena of organic life. Does not the whole of human life attest it? Birth, growth, old age, and death of an individual, family, race, or nation, what is it all but a rhythm? All life-manifestation, then, even in its most intricate form, as exemplified in man, however involved and inscrutable, is only a movement, to which the same general laws of movement which govern throughout the physical universe must be applicable.

When we speak of man, we have a conception of humanity as a whole, and before applying scientific methods to the investigation of his movement, we must accept this as a physical fact. But can any one doubt to-day that all the millions of individuals and all the innumerable types and characters constitute an entity, a unit? Though free to

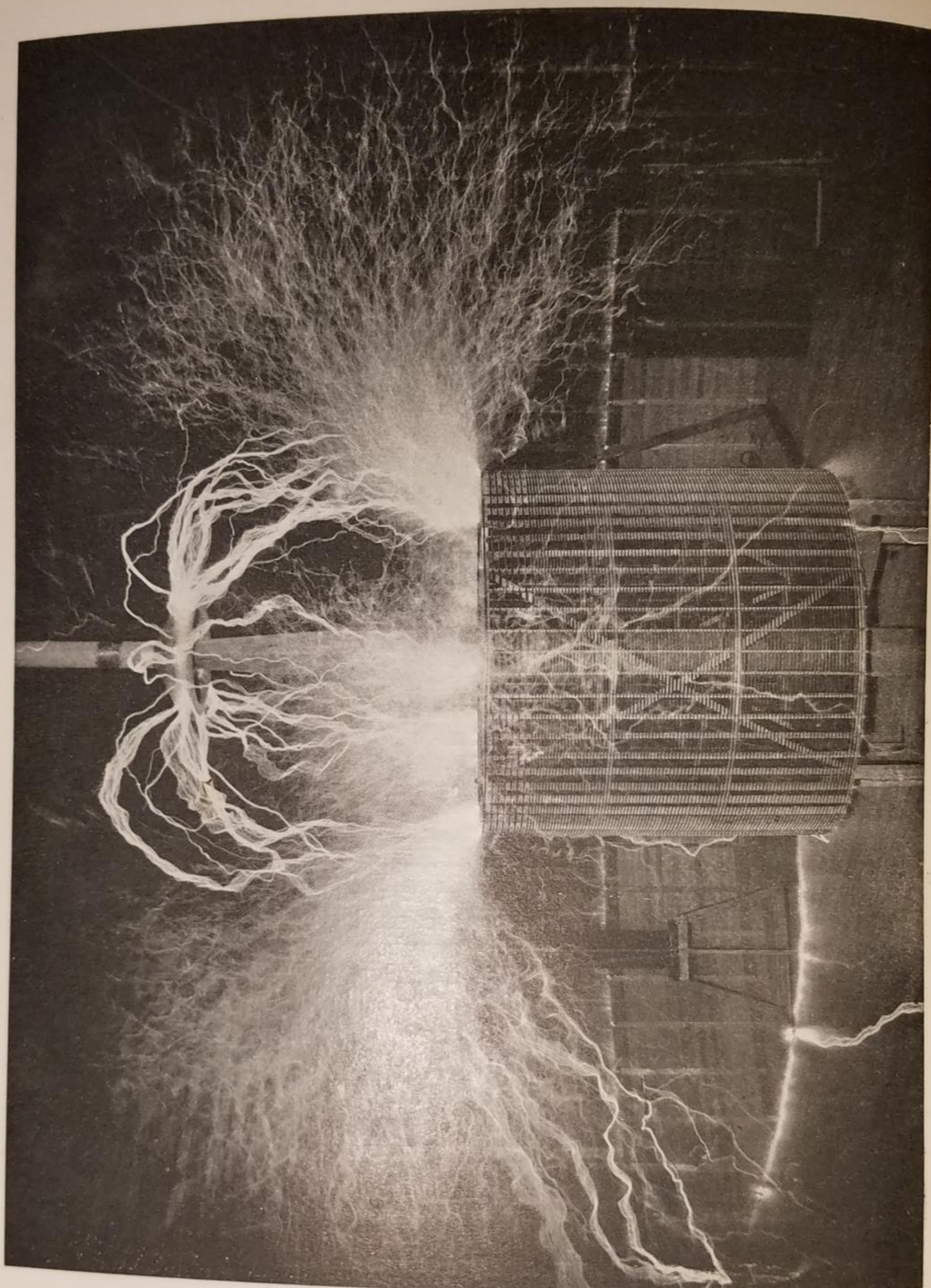


FIG. 1. BURNING THE NITROGEN OF THE ATMOSPHERE.

NOTE TO FIG. 1.—This result is produced by the discharge of an electrical oscillator giving twelve million volts. The electrical pressure, alternating one hundred thousand times per second, excites the normally inert nitrogen, causing it to combine with the oxygen. The flame-like discharge shown in the photograph measures sixty-five feet across.

think and act, we are held together, like the stars in the firmament, with ties inseparable. These ties we cannot see, but we can feel them. I cut myself in the finger, and it pains me: this finger is a part of me. I see a friend hurt, and it hurts me, too: my friend and I are one. And now I see stricken down an enemy, a lump of matter which, of all the lumps of matter in the universe, I care least for, and still it grieves me. Does this not prove that each of us is only a part of a whole?

For ages this idea has been proclaimed in the consummately wise teachings of religion, probably not alone as a means of insuring peace and harmony among men, but as a deeply founded truth. The Buddhist expresses it in one way, the Christian in another, but both say the same: We are all one. Metaphysical proofs are, however, not the only ones which we are able to bring forth in support of this idea. Science, too, recognizes this connectedness of separate individuals, though not quite in the same sense as it admits that the suns, planets, and moons of a constellation are one body, and there can be no doubt that it will be experimentally confirmed in times to come, when our means and methods for investigating psychical and other states and phenomena shall have been brought to great perfection. Still more: this one human being lives on and on. The individual is ephemeral, races and nations come and pass away, but man remains. Therein lies the profound difference between the individual and the whole. Therein, too, is to be found the partial explanation of many of those marvelous phenomena of heredity which are the result of countless centuries of feeble but persistent influence.

Conceive, then, man as a mass urged on by a force. Though this movement is not of a translatory character, implying change of place, yet the general laws of mechanical movement are applicable to it, and the energy associated with this mass can be measured, in accordance with well-known principles, by half the product of the mass with the square of a certain velocity. So, for instance, a cannon-ball which is at rest possesses a certain amount of energy in the form of heat, which we measure in a similar way. We imagine the ball to consist of innumerable minute particles, called atoms or molecules, which vibrate or whirl around one another. We determine their masses and velocities, and from them the energy of each of these minute systems, and adding them all together, we get an idea of the total heat-energy contained in the ball, which is only seemingly at rest. In this purely theoretical estimate this energy may then be calculated by multiplying half of the total mass—that is, half of the sum of all the small masses—with the square of a velocity which is determined from the velocities of the separate particles. In like manner we may conceive of human energy being measured by half the human mass multiplied with the square of a velocity which we are not yet able to compute. But our deficiency in this knowledge will not vitiate the truth of the deductions I shall draw, which rest on the firm basis that the same laws of mass and force govern throughout nature.

Man, however, is not an ordinary mass, consisting of spinning atoms and molecules, and containing merely heat-energy. He is a mass possessed of certain higher qualities by reason of the creative principle of life with which he is endowed. His mass, as the water in an ocean wave, is being continuously exchanged, new taking the place of the old. Not only this, but he grows, propagates, and dies, thus altering his mass independently, both in bulk and density. What is most wonderful of all, he is capable of increasing or diminishing his velocity of movement by the mysterious power he possesses of appropriating more or less energy from other substance, and turning it into motive energy. But in any given moment we may ignore these slow changes and assume that human energy is measured by half the product of man's mass with the square of a certain hypothetical velocity. However we may compute this velocity, and whatever we may take as the standard of its measure, we must, in harmony with this conception, come to the conclusion that the great problem of science is, and always will be, to increase the energy thus defined. Many years ago, stimulated by the perusal of that deeply interesting work, Draper's "History of the Intellectual Development of Europe," depicting so vividly human movement, I recognized that to solve this eternal problem must ever be the chief task of the man of science. Some results of my own efforts to this end I shall endeavor briefly to describe here.

Let, then, in diagram *a*, *M* represent the mass of man. This mass is impelled in one direction by a force *f*, which is resisted by another partly frictional and partly negative force *R*, acting in a direction exactly opposite, and retarding the movement of the mass. Such an antagonistic force is present

in every movement, and must be taken into consideration. The difference between these two forces is the effective force which imparts a velocity V to the mass M in the direction of the arrow on the line representing the force f. In accordance with the pre-

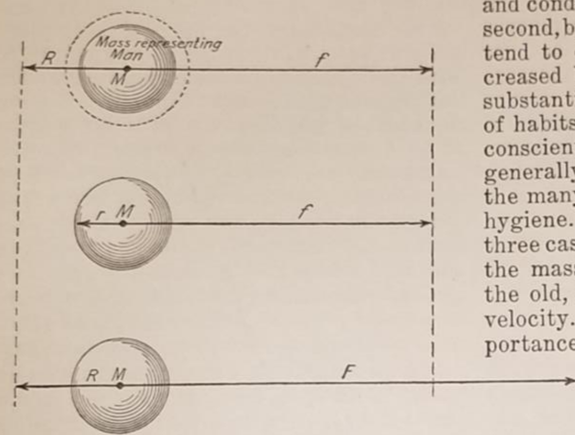


DIAGRAM *a*. THE THREE WAYS OF INCREASING HUMAN ENERGY.

ceding, the human energy will then be given by the product $\frac{1}{2}MV^2=\frac{1}{2}MV\times V$, in which M is the total mass of man in the ordinary interpretation of the term "mass," and V is a certain hypothetical velocity, which, in the present state of science, we are unable exactly to define and determine. To increase the human energy is, therefore, equivalent to increasing this product, and there are, as will readily be seen, only three ways possible to attain this result, which are illustrated in the above diagram. The first way, shown in the top figure, is to increase the mass (as indicated by the dotted circle), leaving the two opposing forces the same. The second way is to reduce the retarding force R to a smaller value r, leaving the mass and the impelling force the same, as diagrammatically shown in the middle figure. The third way, which is illustrated in the last figure, is to increase the impelling force f to a higher value F, while the mass and the retarding force R remain unaltered. Evidently fixed limits exist as regards increase of mass and reduction of retarding force, but the impelling force can be increased indefinitely. Each of these three possible solutions presents a different aspect of the main problem of increasing human energy, which is thus divided into three distinct problems, to be successively considered.

THE FIRST PROBLEM: HOW TO INCREASE THE HUMAN MASS—THE BURNING OF ATMOSPHERIC NITROGEN.

VIEWED generally, there are obviously two ways of increasing the mass of mankind: first, by aiding and maintaining those forces and conditions which tend to increase it; and, second, by opposing and reducing those which tend to diminish it. The mass will be increased by careful attention to health, by substantial food, by moderation, by regularity of habits, by the promotion of marriage, by conscientious attention to the children, and, generally stated, by the observance of all the many precepts and laws of religion and hygiene. But in adding new mass to the old, three cases again present themselves. Either the mass added is of the same velocity as the old, or it is of a smaller or of a higher velocity. To gain an idea of the relative importance of these cases, imagine a train composed of, say, one hundred locomotives running on a track, and suppose that, to increase the energy of the moving mass, four more locomotives are added to the train. If these four move at the same velocity at which the train is going, the total energy will be increased four per cent.; if they are moving at only one half of that velocity, the increase will amount to only one per cent.; if they are moving at twice that velocity, the increase of energy will be sixteen per cent. This simple illustration shows that it is of the greatest importance to add mass of a higher velocity. Stated more to the point, if, for example, the children be of the same degree of enlightenment as the parents,—that is, mass of the "same velocity,"—the energy will simply increase proportionately to the number added. If they are less intelligent or advanced, or mass of "smaller velocity," there will be a very slight gain in the energy; but if they are further advanced, or mass of "higher velocity," then the new generation will add very considerably to the sum total of human energy. Any addition of mass of "smaller velocity," beyond that indispensable amount required by the law expressed in the proverb, "Mens sana in corpore sano," should be strenuously opposed. For instance, the mere development of muscle, as aimed at in some of our colleges, I consider equivalent to adding mass of "smaller velocity," and I would not commend it, although my views were different when I was a student myself. Moderate exercise, insuring the right balance between

mind and body, and the highest efficiency of performance, is, of course, a prime requirement. The above example shows that the most important result to be attained is the education, or the increase of the "velocity," of the mass newly added.

Conversely, it scarcely need be stated that everything that is against the teachings of religion and the laws of hygiene is tending to decrease the mass. Whisky, wine, tea, coffee, tobacco, and other such stimulants are responsible for the shortening of the lives of many, and ought to be used with moderation. But I do not think that rigorous measures of suppression of habits followed through many generations are commendable. It is wiser to preach moderation than abstinence. We have become accustomed to these stimulants, and if such reforms are to be effected, they must be slow and gradual. Those who are devoting their energies to such ends could make themselves far more useful by turning their efforts in other directions, as, for instance, toward providing pure water.

For every person who perishes from the effects of a stimulant, at least a thousand die from the consequences of drinking impure water. This precious fluid, which daily infuses new life into us, is likewise the chief vehicle through which disease and death enter our bodies. The germs of destruction it conveys are enemies all the more terrible as they perform their fatal work unperceived. They seal our doom while we live and enjoy. The majority of people are so ignorant or careless in drinking water, and the consequences of this are so disastrous, that a philanthropist can scarcely use his efforts better than by endeavoring to enlighten those who are thus injuring themselves. By systematic purification and sterilization of the drinking-water the human mass would be very considerably increased. It should be made a rigid rule—which might be enforced by law—to boil or to sterilize otherwise the drinking-water in every household and public place. The mere filtering does not afford sufficient security against infection. All ice for internal uses should be artificially prepared from water thoroughly sterilized. The importance of eliminating germs of disease from the city water is generally recognized, but little is being done to improve the existing conditions, as no satisfactory method of sterilizing great quantities of water has as yet been brought forward. By improved electrical appliances we are now enabled to produce ozone cheaply and in large amounts, and this ideal disinfectant seems to offer a happy solution of the important question.

Gambling, business rush, and excitement, particularly on the exchanges, are causes of much mass-reduction, all the more so because the individuals concerned represent units of higher value. Incapacity of observing the first symptoms of an illness, and careless neglect of the same, are important factors of mortality. In noting carefully every new sign of approaching danger, and making conscientiously every possible effort to avert it, we are not only following wise laws of hygiene in the interest of our well-being and the success of our labors, but we are also complying with a higher moral duty. Every one should consider his body as a priceless gift from one whom he loves above all, as a marvelous work of art, of undescribable beauty and mastery beyond human conception, and so delicate and frail that a word, a breath, a look, nay, a thought, may injure it. Uncleanliness, which breeds disease and death, is not only a self-destructive but a highly immoral habit. In keeping our bodies free from infection, healthful, and pure, we are expressing our reverence for the high principle with which they are endowed. He who follows the precepts of hygiene in this spirit is proving himself, so far, truly religious. Laxity of morals is a terrible evil, which poisons both mind and body, and which is responsible for a great reduction of the human mass in some countries. Many of the present customs and tendencies are productive of similar hurtful results. For example, the society life, modern education and pursuits of women, tending to draw them away from their household duties and make men out of them, must needs detract from the elevating ideal they represent, diminish the artistic creative power, and cause sterility and a general weakening of the race. A thousand other evils might be mentioned, but all put together, in their bearing upon the problem under discussion, they would not equal a single one, the want of food, brought on by poverty, destitution, and famine. Millions of individuals die yearly for want of food, thus keeping down the mass. Even in our enlightened communities, and notwithstanding the many charitable efforts, this is still, in all probability, the chief evil. I do not mean here absolute want of food, but want of healthful nutriment.

How to provide good and plentiful food is, therefore, a most important question of the day. On general principles the raising of cattle as a means of providing food is

objectionable, because, in the sense interpreted above, it must undoubtedly tend to the addition of mass of a "smaller velocity." It is certainly preferable to raise vegetables, and I think, therefore, that vegetarianism is a commendable departure from the established barbarous habit. That we can subsist on plant food and perform our work even to advantage is not a theory, but a well-demonstrated fact. Many races living almost exclusively on vegetables are of superior physique and strength. There is no doubt that some plant food, such as oatmeal, is more economical than meat, and superior to it in regard to both mechanical and mental performance. Such food, moreover, taxes our digestive organs decidedly less, and, in making us more contented and sociable, produces an amount of good difficult to estimate. In view of these facts every effort should be made to stop the wanton and cruel slaughter of animals, which must be destructive to our morals. To free ourselves from animal instincts and appetites, which keep us down, we should begin at the very root from which they spring: we should effect a radical reform in the character of the food.

There seems to be no *philosophical* necessity for food. We can conceive of organized beings living without nourishment, and deriving all the energy they need for the performance of their life-functions from the ambient medium. In a crystal we have the clear evidence of the existence of a formative life-principle, and though we cannot understand the life of a crystal, it is none the less a living being. There may be, besides crystals, other such individualized, material systems of beings, perhaps of gaseous constitution, or composed of substance still more tenuous. In view of this possibility,—nay, probability,—we cannot apodictically deny the existence of organized beings on a planet merely because the conditions on the same are unsuitable for the existence of life as we conceive it. We cannot even, with positive assurance, assert that some of them might not be present here, in this our world, in the very midst of us, for their constitution and life-manifestation may be such that we are unable to perceive them.

The production of artificial food as a means for causing an increase of the human mass naturally suggests itself, but a direct attempt of this kind to provide nourishment does not appear to me rational, at least not for the present. Whether we could thrive on such food is very doubtful. We are the result of ages of continuous adaptation, and we cannot radically change without unforeseen and, in all probability, disastrous consequences. So uncertain an experiment should not be tried. By far the best way, it seems to me, to meet the ravages of the evil, would be to find ways of increasing the productivity of the soil. With this object the preservation of forests is of an importance which cannot be overestimated, and in this connection, also, the utilization of water-power for purposes of electrical transmission, dispensing in many ways with the necessity of burning wood, and tending thereby to forest preservation, is to be strongly advocated. But there are limits in the improvement to be effected in this and similar ways.

To increase materially the productivity of the soil, it must be more effectively fertilized by artificial means. The question of food-production resolves itself, then, into the question how best to fertilize the soil. What it is that made the soil is still a mystery. To explain its origin is probably equivalent to explaining the origin of life itself. The rocks, disintegrated by moisture and heat and wind and weather, were in themselves not capable of maintaining life. Some unexplained condition arose, and some new principle came into effect, and the first layer capable of sustaining low organisms, like mosses, was formed. These, by their life and death, added more of the life-sustaining quality to the soil, and higher organisms could then subsist, and so on and on, until at last highly developed plant and animal life could flourish. But though the theories are, even now, not in agreement as to how fertilization is effected, it is a fact, only too well ascertained, that the soil cannot indefinitely sustain life, and some way must be found to supply it with the substances which have been abstracted from it by the plants. The chief and most valuable among these substances are compounds of nitrogen, and the cheap production of these is, therefore, the key for the solution of the all-important food problem. Our atmosphere contains an inexhaustible amount of nitrogen, and could we but oxidize it and produce these compounds, an incalculable benefit for mankind would follow.

Long ago this idea took a powerful hold on the imagination of scientific men, but an efficient means for accomplishing this result could not be devised. The problem was rendered extremely difficult by the extraordinary inertness of the nitrogen, which refuses to

combine even with oxygen. But here electricity comes to our aid: the dormant affinities of the element are awakened by an electric current of the proper quality. As a lump of coal which has been in contact with oxygen for centuries without burning will combine with it when once ignited, so nitrogen, excited by electricity, will burn. I did not succeed, however, in producing electrical discharges exciting very effectively the atmospheric nitrogen until a comparatively recent date, although I showed, in May, 1891, in a scientific lecture, a novel form of discharge or electrical flame named "St. Elmo's hotfire," which, besides being capable of generating ozone in abundance, also possessed, as I pointed out on that occasion, distinctly the quality of exciting chemical affinities. This discharge or flame was then only three or four inches long, its chemical action was likewise very feeble, and consequently the process of oxidation of the nitrogen was wasteful. How to intensify this action was the question. Evidently electric currents of a peculiar kind had to be produced in order to render the process of nitrogen combustion more efficient.

The first advance was made in ascertaining that the chemical activity of the discharge was very considerably increased by using currents of extremely high frequency or rate of vibration. This was an important improvement, but practical considerations soon set a definite limit to the progress in this direction. Next, the effects of the electrical pressure of the current impulses, of their wave-form and other characteristic features, were investigated. Then the influence of the atmospheric pressure and temperature and of the presence of water and other bodies was studied, and thus the best conditions for causing the most intense chemical action of the discharge and securing the highest efficiency of the process were gradually ascertained. Naturally, the improvements were not quick in coming; still, little by little, I advanced. The flame grew larger and larger, and its oxidizing action more and more intense. From an insignificant brush-discharge a few inches long it developed into a marvelous electrical phenomenon, a roaring blaze, devouring the nitrogen of the atmosphere and measuring sixty or seventy feet across. Thus slowly, almost imperceptibly, possibility became accomplishment. All is not yet done, by any means, but to what a degree my efforts have been rewarded an idea may be gained from an inspection of Fig. 1 (p. 176), which, with its title, is self-explanatory. The flame-like discharge visible is produced by the intense electrical oscillations which pass through the coil shown, and violently agitate the electrified molecules of the air. By this means a strong affinity is created between the two normally indifferent constituents of the atmosphere, and they combine readily, even if no further provision is made for intensifying the chemical action of the discharge. In the manufacture of nitrogen compounds by this method, of course, every possible means bearing upon the intensity of this action and the efficiency of the process will be taken advantage of, and, besides, special arrangements will be provided for the fixation of the compounds formed, as they are generally unstable, the nitrogen becoming again inert after a little lapse of time. Steam is a simple and effective means for fixing permanently the compounds. The result illustrated makes it practicable to oxidize the atmospheric nitrogen in unlimited quantities, merely by the use of cheap mechanical power and simple electrical apparatus. In this manner many compounds of nitrogen may be manufactured all over the world, at a small cost, and in any desired amount, and by means of these compounds the soil can be fertilized and its productiveness indefinitely increased. An abundance of cheap and healthful food, not artificial, but such as we are accustomed to, may thus be obtained. This new and inexhaustible source of food-supply will be of incalculable benefit to mankind, for it will enormously contribute to the increase of the human mass, and thus add immensely to human energy. Soon, I hope, the world will see the beginning of an industry which, in time to come, will, I believe, be in importance next to that of iron.

THE SECOND PROBLEM: HOW TO REDUCE THE FORCE RETARDING THE HUMAN MASS—THE ART OF TELAUTOMATICS.

As before stated, the force which retards the onward movement of man is partly frictional and partly negative. To illustrate this distinction I may name, for example, ignorance, stupidity, and imbecility as some of the purely frictional forces, or resistances devoid of any directive tendency. On the other hand, visionariness, insanity, self-destructive tendency, religious fanaticism, and the like, are all forces of a negative character, acting in definite directions. To reduce or entirely to overcome these dissimilar retarding forces, radically different methods must be employed. One knows, for instance, what

a fanatic may do, and one can take preventive measures, can enlighten, convince, and possibly direct him, turn his vice into virtue; but one does not know, and never can know, what a brute or an imbecile may do, and one must deal with him as with a mass, inert, without mind, let loose by the mad elements. A negative force always implies some quality, not infrequently a high one, though badly directed, which it is possible to turn to good advantage; but a directionless, frictional force involves unavoidable loss. Evidently, then, the first and general answer to the above question is: turn all negative force in the right direction and reduce all frictional force.

There can be no doubt that, of all the frictional resistances, the one that most retards human movement is ignorance. Not without reason said that man of wisdom, Buddha: "Ignorance is the greatest evil in the world." The friction which results from ignorance, and which is greatly increased owing to the numerous languages and nationalities, can be reduced only by the spread of knowledge and the unification of the heterogeneous elements of humanity. No effort could be better spent. But however ignorance may have retarded the onward movement of man in times past, it is certain that, nowadays, negative forces have become of greater importance. Among these there is one of far greater moment than any other. It is called organized warfare. When we consider the millions of individuals, often the ablest in mind and body, the flower of humanity, who are compelled to a life of inactivity and unproductiveness, the immense sums of money daily required for the maintenance of armies and war apparatus, representing ever so much of human energy, all the effort uselessly spent in the production of arms and implements of destruction, the loss of life and the fostering of a barbarous spirit, we are appalled at the inestimable loss to mankind which the existence of these deplorable conditions must involve. What can we do to combat best this great evil?

Law and order absolutely require the maintenance of organized force. No community can exist and prosper without rigid discipline. Every country must be able to defend itself, should the necessity arise. The conditions of to-day are not the result of yesterday, and a radical change cannot be effected to-morrow. If the nations would at once disarm, it is more than likely that a state of things worse than war itself would follow.

Universal peace is a beautiful dream, but not at once realizable. We have seen recently that even the noble effort of the man invested with the greatest worldly power has been virtually without effect. And no wonder, for the establishment of universal peace is, for the time being, a physical impossibility. War is a negative force, and cannot be turned in a positive direction without passing through the intermediate phases. It is the problem of making a wheel, rotating one way, turn in the opposite direction without slowing it down, stopping it, and speeding it up again the other way.

It has been argued that the perfection of guns of great destructive power will stop warfare. So I myself thought for a long time, but now I believe this to be a profound mistake. Such developments will greatly modify, but not arrest it. On the contrary, I think that every new arm that is invented, every new departure that is made in this direction, merely invites new talent and skill, engages new effort, offers a new incentive, and so only gives a fresh impetus to further development. Think of the discovery of gunpowder. Can we conceive of any more radical departure than was effected by this innovation? Let us imagine ourselves living in that period: would we not have thought then that warfare was at an end, when the armor of the knight became an object of ridicule, when bodily strength and skill, meaning so much before, became of comparatively little value? Yet gunpowder did not stop warfare; quite the opposite—it acted as a most powerful incentive. Nor do I believe that warfare can ever be arrested by any scientific or ideal development, so long as similar conditions to those now prevailing exist, because war has itself become a science, and because war involves some of the most sacred sentiments of which man is capable. In fact, it is doubtful whether men who would not be ready to fight for a high principle would be good for anything at all. It is not the mind which makes man, nor is it the body; it is mind and body. Our virtues and our failings are inseparable, like force and matter. When they separate, man is no more.

Another argument, which carries considerable force, is frequently made, namely, that war must soon become impossible because the means of defense are outstripping the means of attack. This is only in accordance with a fundamental law which may be expressed by the statement that it is easier to destroy than to build. This law defines human capacities and human conditions.

Were these such that it would be easier to build than to destroy, man would go on unresisted, creating and accumulating without limit. Such conditions are not of this earth. A being which could do this would not be a man; it might be a god. Defense will always have the advantage over attack, but this alone, it seems to me, can never stop war. By the use of new principles of defense we can render harbors impregnable against attack, but we cannot by such means prevent two war-ships meeting in battle on the high sea. And then, if we follow this idea to its ultimate development, we are led to the conclusion that it would be better for mankind if attack and defense were just oppositely related; for if every country, even the smallest, could surround itself with a wall absolutely impenetrable, and could defy the rest of the world, a state of things would surely be brought on which would be extremely unfavorable to human progress. It is by abolishing all the barriers which separate nations and countries that civilization is best furthered.

Again, it is contended by some that the advent of the flying-machine must bring on universal peace. This, too, I believe to be an entirely erroneous view. The flying-machine is certainly coming, and very soon, but the conditions will remain the same as before. In fact, I see no reason why a ruling power, like Great Britain, might not govern the air as well as the sea. Without wishing to put myself on record as a prophet, I do not hesitate to say that the next years will see the establishment of an "air-power," and its center may not be far from New York. But, for all that, men will fight on merrily.

The ideal development of the war principle would ultimately lead to the transformation of the whole energy of war into purely potential, explosive energy, like that of an electrical condenser. In this form the war-energy could be maintained without effort; it would need to be much smaller in amount, while incomparably more effective.

As regards the security of a country against foreign invasion, it is interesting to note that it depends only on the relative, and not on the absolute, number of the individuals or magnitude of the forces, and that, if every country should reduce the war-force in the same ratio, the security would remain unaltered. An international agreement with the object of reducing to a minimum the war-force which, in view of the present still imperfect education of the masses, is absolutely indispensable, would, therefore, seem to be the first rational step to take toward diminishing the force retarding human movement.

Fortunately, the existing conditions cannot continue indefinitely, for a new element is beginning to assert itself. A change for the better is imminent, and I shall now endeavor to show what, according to my ideas, will be the first advance toward the establishment of peaceful relations between nations, and by what means it will eventually be accomplished.

Let us go back to the early beginning, when the law of the stronger was the only law. The light of reason was not yet kindled, and the weak was entirely at the mercy of the strong. The weak individual then began to learn how to defend himself. He made use of a club, stone, spear, sling, or bow and arrow, and in the course of time, instead of physical strength, intelligence became the chief deciding factor in the battle. The wild character was gradually softened by the awakening of noble sentiments, and so, imperceptibly, after ages of continued progress, we have come from the brutal fight of the unreasoning animal to what we call the "civilized warfare" of to-day, in which the combatants shake hands, talk in a friendly way, and smoke cigars in the entr'actes, ready to engage again in deadly conflict at a signal. Let pessimists say what they like, here is an absolute evidence of great and gratifying advance.

But now, what is the next phase in this evolution? Not peace as yet, by any means. The next change which should naturally follow from modern developments should be the continuous diminution of the number of individuals engaged in battle. The apparatus will be one of specifically great power, but only a few individuals will be required to operate it. This evolution will bring more and more into prominence a machine or mechanism with the fewest individuals as an element of warfare, and the absolutely unavoidable consequence of this will be the abandonment of large, clumsy, slowly moving, and unmanageable units. Greatest possible speed and maximum rate of energy-delivery by the war apparatus will be the main object. The loss of life will become smaller and smaller, and finally, the number of the individuals continuously diminishing, merely machines will meet in a contest without bloodshed, the nations being simply interested, ambitious spectators. When this happy condition is realized, peace will be assured. But, no matter to what degree of perfection rapid-

fire guns, high-power cannon, explosive projectiles, torpedo-boats, or other implements of war may be brought, no matter how destructive they may be made, that condition can never be reached through any such development. All such implements require men for their operation; men are indispensable parts of the machinery. Their object is to kill and to destroy. Their power resides in their capacity for doing evil. So long as men meet in battle, there will be bloodshed. Bloodshed will ever keep up barbarous passion. To break this fierce spirit, a radical departure must be made, an entirely new principle must be introduced, something that never existed before in warfare—a principle which will forcibly, unavoidably, turn the battle into a mere spectacle, a play, a contest without loss of blood. To bring on this result men must be dispensed with: machine must fight machine. But how accomplish that which seems impossible? The answer is simple enough: produce a machine capable of acting as though it were part of a human being—no mere mechanical contrivance, comprising levers, screws, wheels, clutches, and nothing more, but a machine embodying a higher principle, which will enable it to perform its duties as though it had intelligence, experience, reason, judgment, a mind! This conclusion is the result of my thoughts and observations which have extended through virtually my whole life, and I shall now briefly describe how I came to accomplish that which at first seemed an unrealizable dream.

A long time ago, when I was a boy, I was afflicted with a singular trouble, which seems to have been due to an extraordinary excitability of the retina. It was the appearance of images which, by their persistence, marred the vision of real objects and interfered with thought. When a word was said to me, the image of the object which it designated would appear vividly before my eyes, and many times it was impossible for me to tell whether the object I saw was real or not. This caused me great discomfort and anxiety, and I tried hard to free myself of the spell. But for a long time I tried in vain, and it was not, as I still clearly recollect, until I was about twelve years old that I succeeded for the first time, by an effort of the will, in banishing an image which presented itself. My happiness will never be as complete as it was then, but, unfortunately (as I thought at that time), the old trouble returned, and with it my anxiety. Here it was that the observations to which I refer began. I noted, namely, that whenever the image of an object appeared before my eyes I had seen something which reminded me of it. In the first instances I thought this to be purely accidental, but soon I convinced myself that it was not so. A visual impression, consciously or unconsciously received, invariably preceded the appearance of the image. Gradually the desire arose in me to find out, every time, what caused the images to appear, and the satisfaction of this desire soon became a necessity. The next observation I made was that, just as these images followed as a result of something I had seen, so also the thoughts which I conceived were suggested in like manner. Again, I experienced the same desire to locate the image which caused the thought, and this search for the original visual impression soon grew to be a second nature. My mind became automatic, as it were, and in the course of years of continued, almost unconscious performance, I acquired the ability of locating every time and, as a rule, instantly the visual impression which started the thought. Nor is this all. It was not long before I was aware that also all my movements were prompted in the same way, and so, searching, observing, and verifying continuously, year after year, I have, by every thought and every act of mine, demonstrated, and do so daily, to my absolute satisfaction, that I am an automaton endowed with power of movement, which merely responds to external stimuli beating upon my sense organs, and thinks and acts and moves accordingly. I remember only one or two cases in all my life in which I was unable to locate the first impression which prompted a movement or a thought, or even a dream.

With these experiences it was only natural that, long ago, I conceived the idea of constructing an automaton which would mechanically represent me, and which would respond, as I do myself, but, of course, in a much more primitive manner, to external influences. Such an automaton evidently had to have motive power, organs for locomotion, directive organs, and one or more sensitive organs so adapted as to be excited by external stimuli. This machine would, I reasoned, perform its movements in the manner of a living being, for it would have all the chief mechanical characteristics or elements of the same. There was still the capacity for growth, propagation, and, above all, the mind which would be wanting to make the model complete. But growth was not necessary in this case, since a machine could be manufactured full-grown, so to

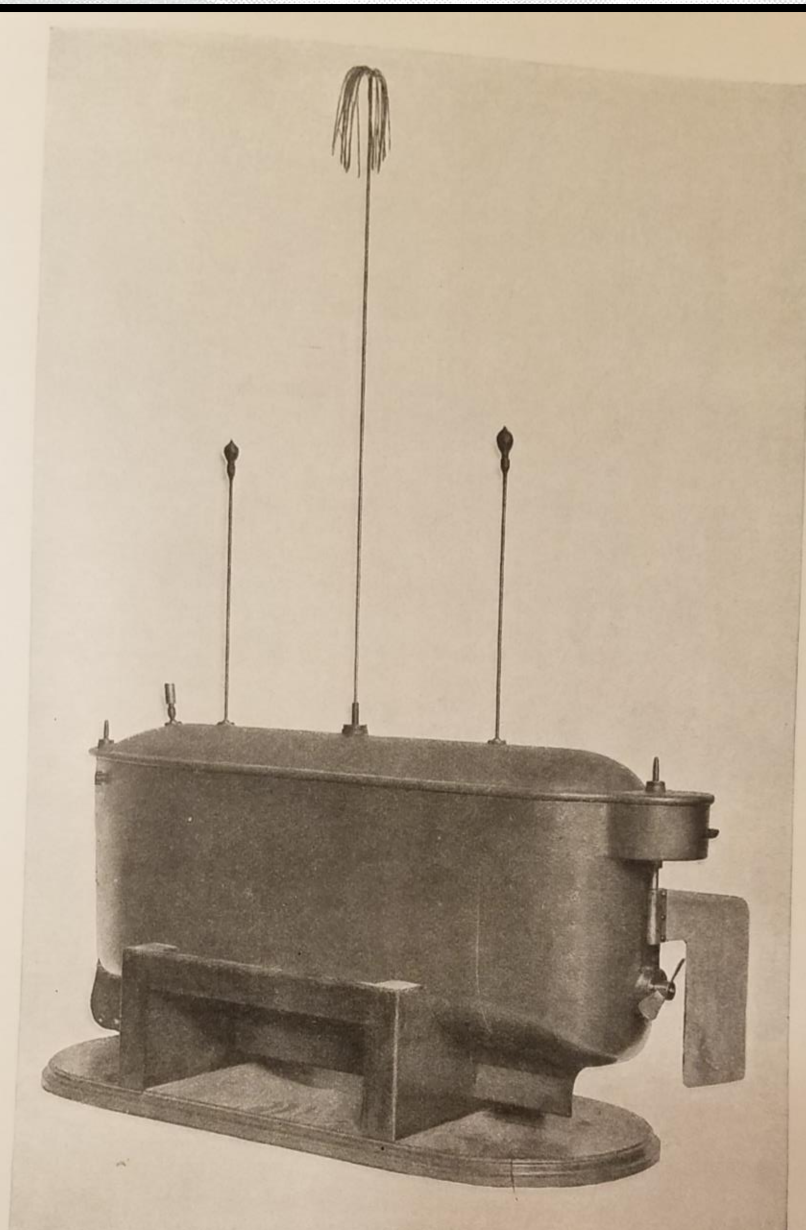


FIG. 2. THE FIRST PRACTICAL TELAUTOMATON.

A machine having all its bodily or translatory movements and the operations of the interior mechanism controlled from a distance without wires. The crewless boat shown in the photograph contains its own motive power, propelling- and steering-machinery, and numerous other accessories, all of which are controlled by transmitting from a distance, without wires, electrical oscillations to a circuit carried by the boat and adjusted to respond only to these oscillations.

speak. As to the capacity for propagation, it could likewise be left out of consideration, for in the mechanical model it merely signified a process of manufacture. Whether the automaton be of flesh and bone, or of wood and steel, it mattered little, provided it could perform all the duties required of it like an intelligent being. To do so, it had to have an element corresponding to the mind, which would effect the control of all its movements and operations, and cause it to act, in any unforeseen case that might present itself, with knowledge, reason, judgment, and experience. But this element I could easily embody in it by conveying to it my own intelligence, my own understanding. So this invention was evolved, and so a new art came into existence, for which the name



FIG. 3. EXPERIMENT TO ILLUSTRATE THE SUPPLYING OF ELECTRICAL ENERGY THROUGH A SINGLE WIRE WITHOUT RETURN.

An ordinary incandescent lamp, connected with one or both of its terminals to the wire forming the upper free end of the coil shown in the photograph, is lighted by electrical vibrations conveyed to it through the coil from an electrical oscillator, which is worked only to one fifth of one per cent. of its full capacity.

"telautomatics" has been suggested, which means the art of controlling the movements and operations of distant automatons.

This principle evidently was applicable to any kind of machine that moves on land or in the water or in the air. In applying it practically for the first time, I selected a boat (see Fig. 2). A storage battery placed within it furnished the motive power. The propeller, driven by a motor, represented the locomotive organs. The rudder, controlled by another motor likewise driven by the battery, took the place of the directive organs. As to the sensitive organ, obviously the first thought was to utilize a device responsive to rays of light, like a selenium cell, to represent the human eye. But upon closer inquiry I found that, owing to experimental and other difficulties, no thoroughly satisfactory control of the automaton could be effected by light, radiant heat, Hertzian radiations, or by rays in general, that is, disturbances which pass in straight lines through space. One of the reasons was that any obstacle coming between the operator and the distant automaton would place it beyond his control. Another reason was that the sensitive device representing the eye would have to be in a definite position with respect to the distant controlling apparatus, and this necessity would impose great limitations in the control. Still another and very important reason was that, in using rays, it would be difficult, if not impossible, to give to the automaton individual features or characteristics distinguishing it from other machines of this kind. Evidently the automaton should respond only to an individual call, as a person responds to a name. Such considerations led me to conclude that the sensitive device of the machine should correspond to the ear rather than to the eye of a human being, for in this case its actions could be controlled irrespective of intervening obstacles, regardless of its position relative to the distant controlling apparatus, and, last, but not least, it would remain deaf and unresponsive, like a faithful servant, to all calls but that of its master. These requirements made it imperative to use, in the control of the automaton, instead of light- or other rays, waves or disturbances which propagate in all directions through space, like sound, or which follow a path of least resistance, however curved. I attained the result aimed at by means of an electric circuit placed within the boat, and adjusted, or "tuned," exactly to electrical vibrations of the proper kind transmitted to it from a

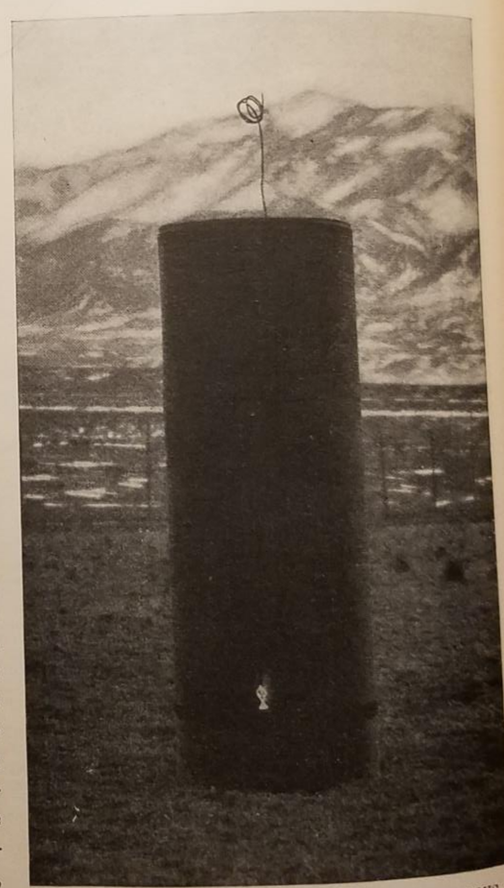


FIG. 4. EXPERIMENT TO ILLUSTRATE THE TRANSMISSION OF ELECTRICAL ENERGY THROUGH THE EARTH WITHOUT WIRE.

The coil shown in the photograph has its lower end or terminal connected to the ground, and is exactly attuned to the vibrations of a distant electrical oscillator. The lamp lighted is in an independent wire loop, energized by induction from the coil excited by the electrical vibrations transmitted to it through the ground from the oscillator, which is worked only to five per cent. of its full capacity.

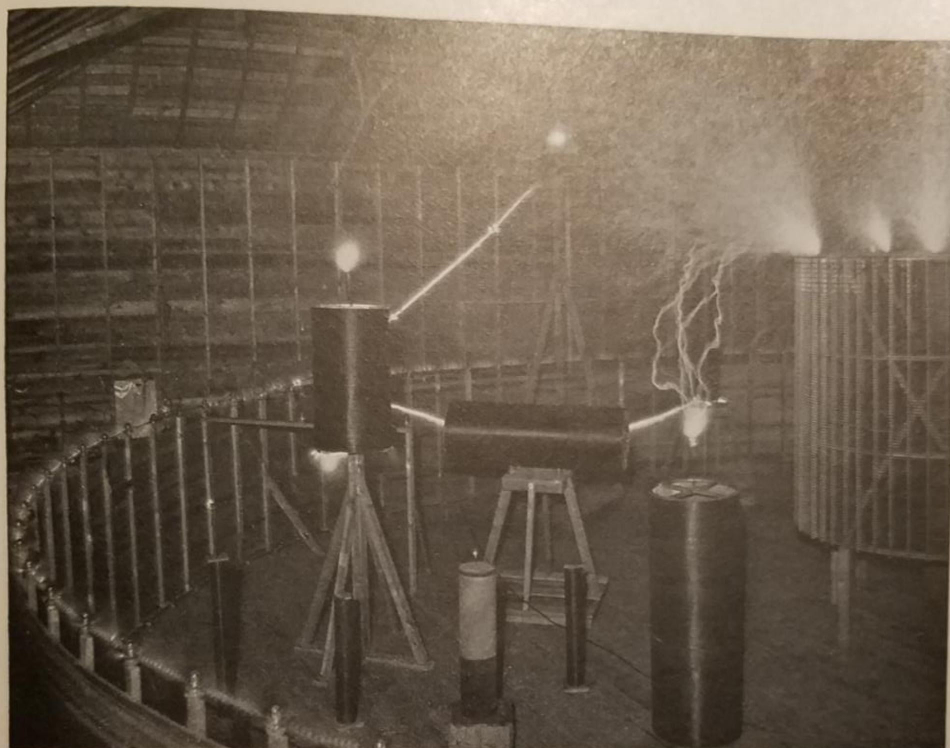


FIG. 5. PHOTOGRAPHIC VIEW OF COILS RESPONDING TO ELECTRICAL OSCILLATIONS.

The picture shows a number of coils, differently attuned and responding to the vibrations transmitted to them through the earth from an electrical oscillator. The large coil on the right, discharging strongly, is tuned to the fundamental vibration, which is fifty thousand per second; the two larger vertical coils to twice that number; the smaller white wire coil to four times that number, and the remaining small coils to higher tones. The vibrations produced by the oscillator were so intense that they affected perceptibly a small coil tuned to the twenty-sixth higher tone.

distant "electrical oscillator." This circuit, in responding, however feebly, to the transmitted vibrations, affected magnets and other contrivances, through the medium of which were controlled the movements of the propeller and rudder, and also the operations of numerous other appliances.

By the simple means described the knowledge, experience, judgment—the mind, so to speak—of the distant operator were embodied in that machine, which was thus enabled to move and to perform all its operations with reason and intelligence. It behaved just like a blindfolded person obeying directions received through the ear.

The automatons so far constructed had "borrowed minds," so to speak, as each merely formed part of the distant operator who conveyed to it his intelligent orders; but this art is only in the beginning. I purpose to show that, however impossible it may now seem, an automaton may be contrived which will have its "own mind," and by this I mean that it will be able, independent of any operator, left entirely to itself, to perform, in response to external influences affecting its sensitive organs, a great variety of acts and operations as if it had intelligence. It will be able to follow a course laid out or to obey orders given far in advance; it will be capable of distinguishing between what it ought and what it ought not to do, and of making experiences or, otherwise stated, of recording impressions which will definitely affect its subsequent actions. In fact, I have already conceived such a plan.

Although I evolved this invention many years ago and explained it to my visitors very frequently in my laboratory demonstrations, it was not until much later, long after I had perfected it, that it became known, when, naturally enough, it gave rise to much discussion and to sensational reports. But the true significance of this new art was not grasped by the majority, nor was the great force of the underlying principle recognized. As nearly as I could judge from the numerous comments which then appeared, the results I had obtained were considered as entirely impossible. Even the few who were disposed to admit the practicability of the

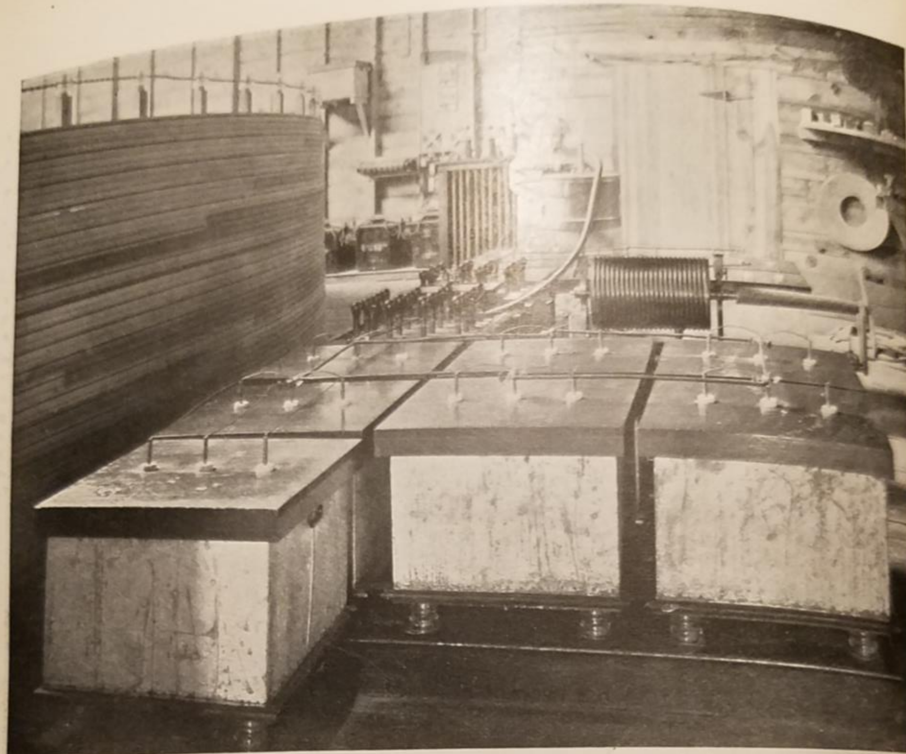


FIG. 6. PHOTOGRAPHIC VIEW OF THE ESSENTIAL PARTS OF THE ELECTRICAL OSCILLATOR USED IN THE EXPERIMENTS DESCRIBED.

invention saw in it merely an automobile torpedo, which was to be used for the purpose of blowing up battle-ships, with doubtful success. The general impression was that I contemplated simply the steering of such a vessel by means of Hertzian or other rays. There are torpedoes steered electrically by wires, and there are means of communicating without wires, and the above was, of course, an obvious inference. Had I accomplished nothing more than this, I should have made a small advance indeed. But the art I have evolved does not contemplate merely the change of direction of a moving vessel; it affords a means of absolutely controlling, in every respect, all the innumerable translatory movements, as well as the operations of all the internal organs, no matter how many, of an individualized automaton. Criticisms to the effect that the control of the automaton could be interfered with were made by people who do not even dream of the wonderful results which can be accomplished by the use of electrical vibrations. The world moves slowly, and new truths are difficult to see. Certainly, by the use of this principle, an arm for attack as well as defense may be provided, of a destructiveness all the greater as the principle is applicable to submarine and aërial vessels. There is virtually no restriction as to the amount of explosive it can carry, or as to the distance at which it can strike, and failure is almost impossible. But the force of this new principle does not wholly reside in its destructiveness. Its advent introduces into warfare an element which never existed before—a fighting-machine without men as a means of attack and defense. The continuous development in this direction must ultimately make war a mere contest of machines without men and without loss of life—a condition which would have been impossible without this new departure, and which, in my opinion, must be reached as preliminary to permanent peace. The future will either bear out or disprove these views. My ideas on this subject have been put forth with deep conviction, but in a humble spirit.

The establishment of permanent peaceful relations between nations would most effectively reduce the force retarding the human mass, and would be the best solution of this great human problem. But will the dream of universal peace ever be realized? Let us hope that it will. When all darkness shall be dissipated by the light of science, when all nations shall be merged into one, and

patriotism shall be identical with religion, when there shall be one language, one country, one end, then the dream will have become reality.

THE THIRD PROBLEM: HOW TO INCREASE THE FORCE ACCELERATING THE HUMAN MASS—THE HARNESSING OF THE SUN'S ENERGY.

OF the three possible solutions of the main problem of increasing human energy, this is by far the most important to consider, not only because of its intrinsic significance, but also because of its intimate bearing on all the many elements and conditions which determine the movement of humanity. In order to proceed systematically, it would be necessary for me to dwell on all those considerations which have guided me from the outset in my efforts to arrive at a solution, and which have led me, step by step, to the results I shall now describe. As a preliminary study of the problem an analytical investigation, such as I have made, of the chief forces which determine the onward movement, would be of advantage, particularly in conveying an idea of that hypothetical "velocity" which, as explained in the beginning, is a measure of human energy; but to deal with this specifically here, as I would desire, would lead me far beyond the scope of the present subject. Suffice it to state that the resultant of all these forces is always in the direction of reason, which, therefore, determines, at any time, the direction of human movement. This is to say that every effort which is scientifically applied, rational, useful, or practical, must be in the direction in which the mass is moving. The practical, rational man, the observer, the man of business, he who reasons, calculates, or determines in advance, carefully applies his effort so that when coming into effect it will be in the direction of the movement, making it thus most efficient, and in this knowledge and ability lies the secret of his success. Every new fact discovered, every new experience or new element added to our knowledge and entering into the domain of reason, affects the same and, therefore, changes

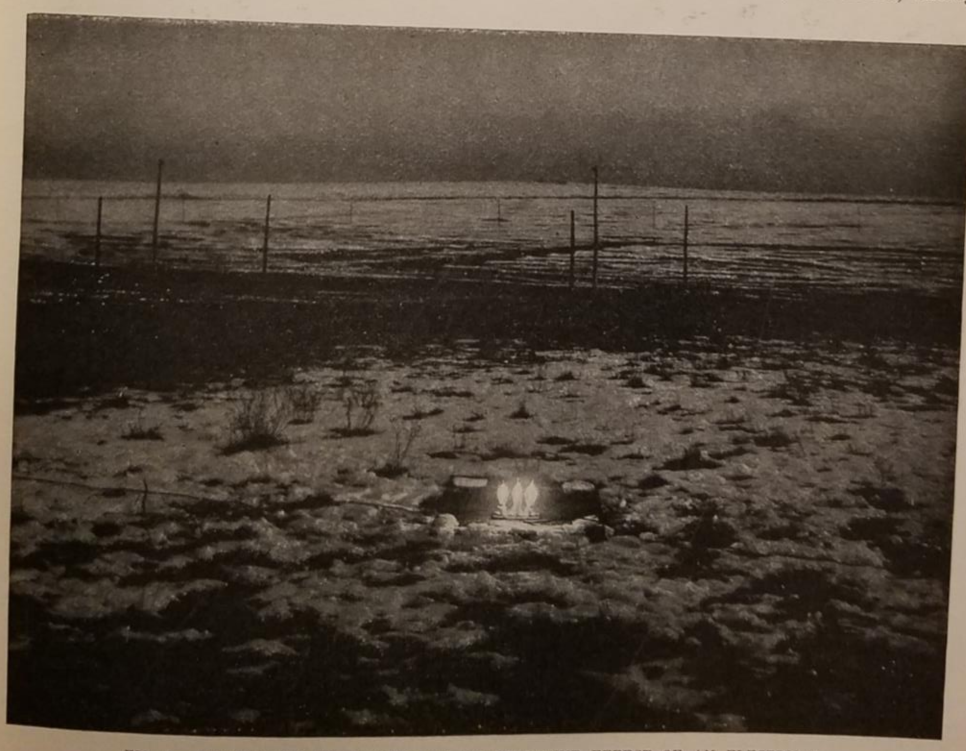


FIG. 7. EXPERIMENT TO ILLUSTRATE AN INDUCTIVE EFFECT OF AN ELECTRICAL OSCILLATOR OF GREAT POWER.

The photograph shows three ordinary incandescent lamps lighted to full candle-power by currents induced in a local loop consisting of a single wire forming a square of fifty feet each side, which includes the lamps, and which is at a distance of one hundred feet from the primary circuit energized by the oscillator. The loop likewise includes an electrical condenser, and is exactly attuned to the vibrations of the oscillator, which is worked at less than five per cent. of its total capacity.

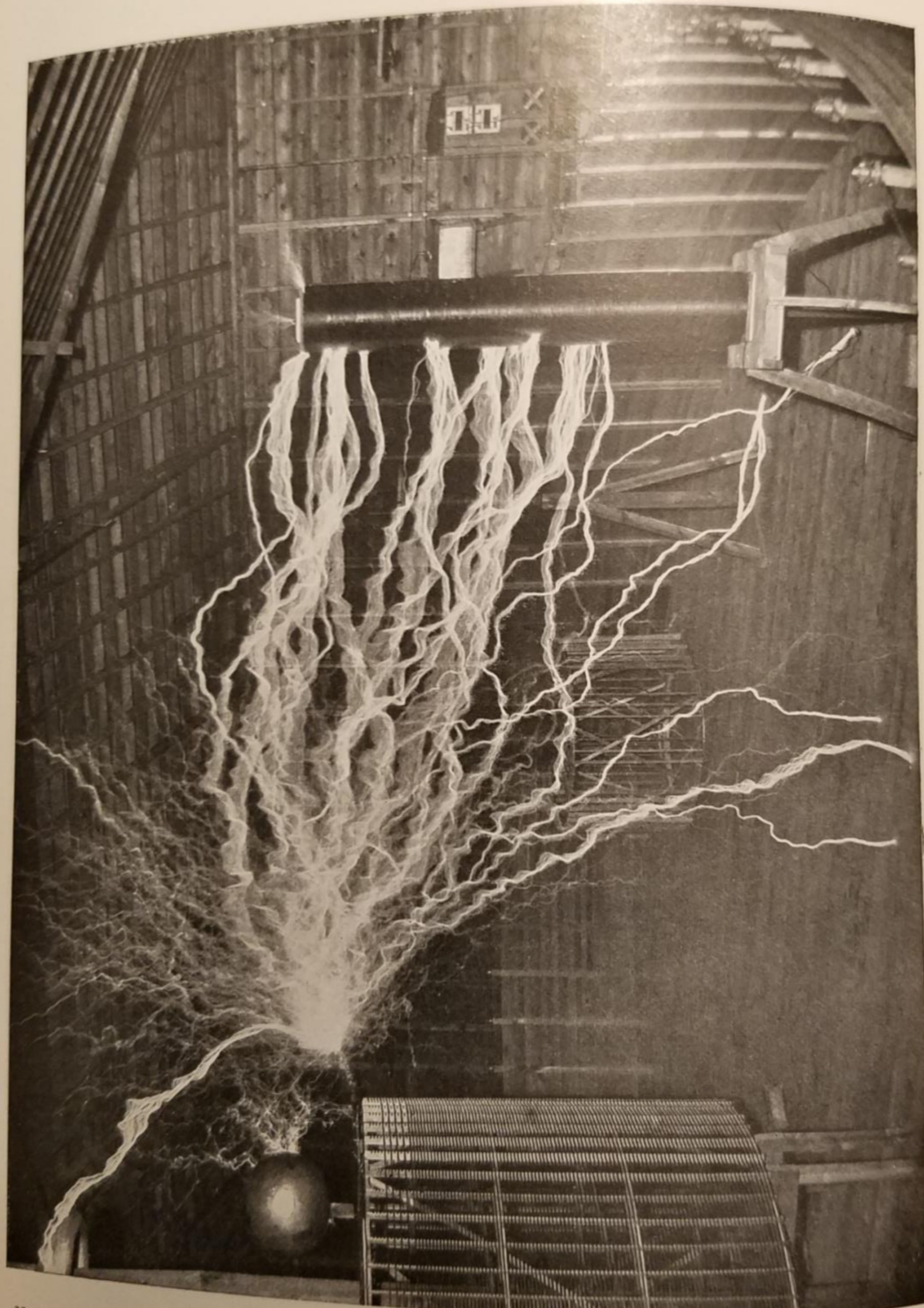


FIG. 8. EXPERIMENT TO ILLUSTRATE THE CAPACITY OF THE OSCILLATOR FOR PRODUCING ELECTRICAL EXPLOSIONS OF GREAT POWER.

NOTE TO FIG. 8.—The coil, partly shown in the photograph, creates an alternative movement of electricity from the earth into a large reservoir and back at the rate of one hundred thousand alternations per second. The adjustments are such that the reservoir is filled full and bursts at each alternation just at the moment when the electrical pressure reaches the maximum. The discharge escapes with a deafening noise, striking an unconnected coil twenty-two feet away, and creating such a commotion of electricity in the earth that sparks an inch long can be drawn from a water-main at a distance of three hundred feet from the laboratory.

100 turns on secondary

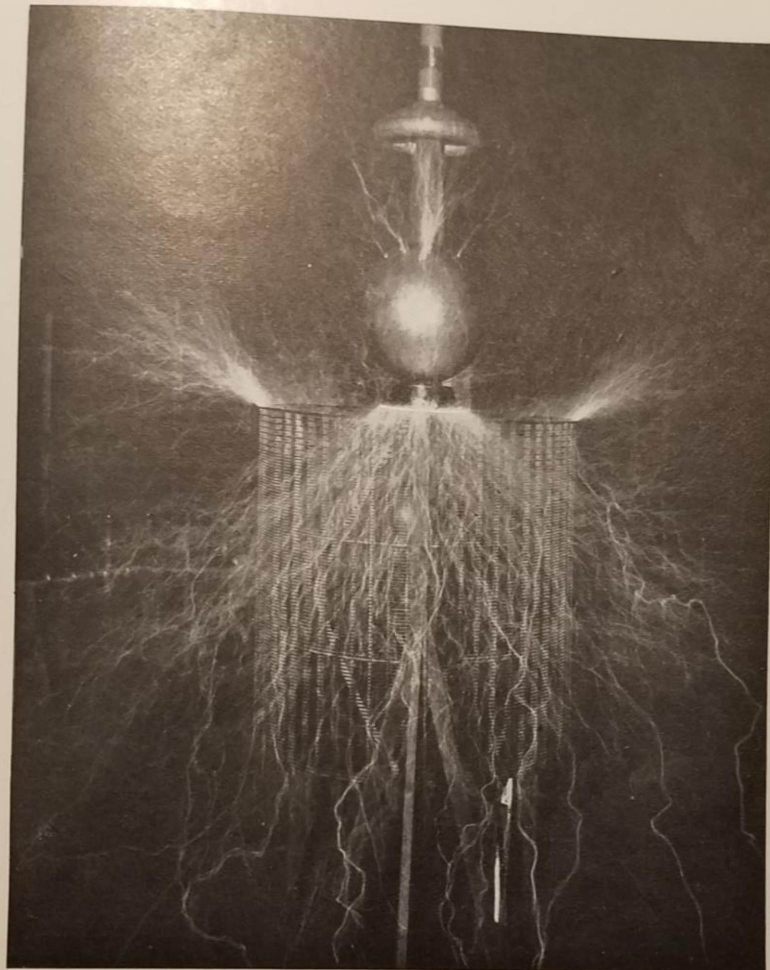


FIG. 9. EXPERIMENT TO ILLUSTRATE THE CAPACITY OF THE OSCILLATOR FOR CREATING A GREAT ELECTRICAL MOVEMENT.

The ball shown in the photograph, covered with a polished metallic coating of twenty square feet of surface, represents a large reservoir of electricity, and the inverted tin pan underneath, with a sharp rim, a big opening through which the electricity can escape before filling the reservoir. The quantity of electricity set in movement is so great that, although most of it escapes through the rim of the pan or opening provided, the ball or reservoir is nevertheless alternately emptied and filled to overflowing (as is evident from the discharge escaping on the top of the ball) one hundred and fifty thousand times per second.

the direction of the movement, which, however, must always take place along the resultant of all those efforts which, at that time, we designate as reasonable, that is, self-preserving, useful, profitable, or practical. These efforts concern our daily life, our necessities and comforts, our work and business, and it is these which drive man onward.

But looking at all this busy world about us, on all this complex mass as it daily throbs and moves, what is it but an immense clockwork driven by a spring? In the morning, when we rise, we cannot fail to note that all the objects about us are manufactured by machinery: the water we use is lifted by steam-power; the trains bring our breakfast from distant localities; the elevators in our dwelling and in our office building, the cars that carry us there, are all driven by power; in all our daily errands, and in our very life-pursuit, we depend upon it; all the objects we see tell us of it; and when we return to our machine-made dwelling at night, lest we should forget it, all the material comforts of our home, our cheering stove and lamp, remind us how much we depend on power. And when there is an accidental stoppage of the machinery, when the city is snow-bound, or the life-sustaining movement otherwise temporarily arrested, we are affrighted to realize

speculations and theories, considering man as a mass moved by a force, viewing his inexplicable movement in the light of a mechanical one, and applying the simple principles of mechanics to the analysis of the same until I arrived at these solutions, only to realize that they were taught to me in my early childhood. These three words sound the key-notes of the Christian religion. Their scientific meaning and purpose are now clear to me: food to increase the mass, peace to diminish the retarding force, and work to increase the force accelerating human movement. These are the only three solutions which are possible of that great problem, and all of them have one object, one end, namely, to increase human energy. When we recognize this, we cannot help wondering how profoundly wise and scientific and how immensely practical the Christian religion is, and in what a marked contrast it stands in this respect to other religions. It is unmistakably the result of practical experiment and scientific observation which have extended through ages, while other religions seem to be the outcome of merely abstract reasoning. Work, untiring effort, useful and accumulative, with periods of rest and recuperation aiming at higher efficiency, is its chief and ever-recurring command. Thus we are inspired both by Christianity and Science to do our utmost toward increasing the performance of mankind. This most important of human problems I shall now specifically consider.

THE SOURCE OF HUMAN ENERGY—THE THREE WAYS OF DRAWING ENERGY FROM THE SUN.

FIRST let us ask: Whence comes all the motive power? What is the spring that drives all? We see the ocean rise and fall, the rivers flow, the wind, rain, hail, and snow beat on our windows, the trains and steamers come and go; we hear the rattling noise of carriages, the voices from the street; we feel, smell, and taste; and we think of all this. And all this movement, from the surging of the mighty ocean to that subtle movement concerned in our thought, has but one common cause. All this energy emanates from one single center, one single source—the sun. The sun is the spring that drives all. The sun maintains all human life and supplies all human energy. Another answer we have now found to the above great question: To increase the force accelerating human movement means to turn to the uses of man more of the sun's energy. We honor and revere those great men of bygone times whose names are linked with immortal achievements, who have proved themselves benefactors of humanity—the religious reformer with his wise maxims of life, the philosopher with his deep truths, the mathematician with his formulæ, the physicist with his laws, the discoverer with his principles and secrets wrested from nature, the artist with his forms of the beautiful; but who honors him, the greatest of all,—who can tell the name of him,—who first turned to use the sun's energy to save the effort of a weak fellow-creature? That was man's first act of scientific philanthropy, and its consequences have been incalculable.

From the very beginning three ways of drawing energy from the sun were open to man. The savage, when he warmed his frozen limbs at a fire kindled in some way, availed himself of the energy of the sun stored in the burning material. When he carried a bundle of branches to his cave and burned them there, he made use of the sun's stored energy transported from one to another locality. When he set sail to his canoe, he utilized the energy of the sun supplied to the atmosphere or ambient medium. There can be no doubt that the first is the oldest way. A fire, found accidentally, taught the savage to appreciate its beneficial heat. He then very likely conceived the idea of carrying the glowing embers to his abode. Finally he learned to use the force of a swift current of water or air. It is characteristic of modern development that progress has been effected in the same order. The utilization of the energy stored in wood or coal, or, generally speaking, fuel, led to the steam-engine. Next a great stride in advance was made in energy-transportation by the use of electricity, which permitted the transfer of energy from one locality to another without transporting the material. But as to the utilization of the energy of the ambient medium, no radical step forward has as yet been made known.

The ultimate results of development in these three directions are: first, the burning of coal by a cold process in a battery; second, the efficient utilization of the energy of the ambient medium; and, third, the transmission without wires of electrical energy to any distance. In whatever way these results may be arrived at, their practical application will necessarily involve an extensive use of iron, and this invaluable metal will undoubtedly be an essential element in the further de-

velopment along these three lines. If we succeed in burning coal by a cold process and thus obtaining electrical energy in an efficient and inexpensive manner, we shall require in many practical uses of this energy electric motors—that is, iron. If we are successful in deriving energy from the ambient medium, we shall need, both in the obtainment and utilization of the energy, machinery—again, iron. If we realize the transmission of electrical energy without wires on an industrial scale, we shall be compelled to use extensively electric generators—once more, iron. Whatever we may do, iron will probably be the chief means of accomplishment in the near future, possibly more so than in the past. How long its reign will last is difficult to tell, for even now aluminium is looming up as a threatening competitor. But for the time being, next to providing new resources of energy, it is of the greatest importance to make improvements in the manufacture and utilization of iron. Great advances are possible in these latter directions, which, if brought about, would enormously increase the useful performance of mankind.

GREAT POSSIBILITIES OFFERED BY IRON FOR INCREASING HUMAN PERFORMANCE—ENORMOUS WASTE IN IRON MANUFACTURE.

Iron is by far the most important factor in modern progress. It contributes more than any other industrial product to the force accelerating human movement. So general is the use of this metal, and so intimately is it connected with all that concerns our life, that it has become as indispensable to us as the very air we breathe. Its name is synonymous with usefulness. But, however great the influence of iron may be on the present human development, it does not add to the force urging man onward nearly as much as it might. First of all, its manufacture as now carried on is connected with an appalling waste of fuel—that is, waste of energy. Then, again, only a part of all the iron produced is applied for useful purposes. A good part of it goes to create frictional resistances, while still another large part is the means of developing negative forces greatly retarding human movement. Thus the negative force of war is almost wholly represented in iron. It is impossible to estimate with any degree of accuracy the magnitude of this greatest of all retarding forces, but it is certainly very considerable. If the present positive impelling force due to all useful applications of iron be represented by ten, for instance, I should not think it exaggeration to estimate the negative force of war, with due consideration of all its retarding influences and results, at, say, six. On the basis of this estimate the effective impelling force of iron in the positive direction would be measured by the difference of these two numbers, which is four. But if, through the establishment of universal peace, the manufacture of war machinery should cease, and all struggle for supremacy between nations should be turned into healthful, ever active and productive commercial competition, then the positive impelling force due to iron would be measured by the sum of those two numbers, which is sixteen—that is, this force would have four times its present value. This example is, of course, merely intended to give an idea of the immense increase in the useful performance of mankind which would result from a radical reform of the iron industries supplying the implements of warfare.

A similar inestimable advantage in the saving of energy available to man would be secured by obviating the great waste of coal which is inseparably connected with the present methods of manufacturing iron. In some countries, as in Great Britain, the hurtful effects of this squandering of fuel are beginning to be felt. The price of coal is constantly rising, and the poor are made to suffer more and more. Though we are still far from the dreaded "exhaustion of the coal-fields," philanthropy commands us to invent novel methods of manufacturing iron, which will not involve such barbarous waste of this valuable material from which we derive at present most of our energy. It is our duty to coming generations to leave this store of energy intact for them, or at least not to touch it until we shall have perfected processes for burning coal more efficiently. Those who are to come after us will need fuel more than we do. We should be able to manufacture the iron we require by using the sun's energy, without wasting any coal at all. As an effort to this end the idea of smelting iron ores by electric currents obtained from the energy of falling water has naturally suggested itself to many. I have myself spent much time in endeavoring to evolve such a practical process, which would enable iron to be manufactured at small cost. After a prolonged investigation of the subject, finding that it was unprofitable to use the currents generated directly for smelting the ore, I devised a method which is far more economical.

THE COMING AGE OF ALUMINIUM—DOOM OF THE COPPER INDUSTRY—THE GREAT CIVILIZING POTENCY OF THE NEW METAL.

WITH the advances made in iron of late years we have arrived virtually at the limits of improvement. We cannot hope to increase very materially its tensile strength, elasticity, hardness, or malleability, nor can we expect to make it much better as regards its magnetic qualities. More recently a notable gain was secured by the mixture of a small percentage of nickel with the iron, but there is not much room for further advance in this direction. New discoveries may be expected, but they cannot greatly add to the valuable properties of the metal, though they may considerably reduce the cost of manufacture. The immediate future of iron is assured by its cheapness and its unrivaled mechanical and magnetic qualities. These are such that no other product can compete with it now. But there can be no doubt that, at a time not very distant, iron, in many of its now uncontested domains, will have to pass the scepter to another: the coming age will be the age of aluminium. It is only seventy years since this wonderful metal was discovered by Woehler, and the aluminium industry, scarcely forty years old, commands already the attention of the entire world. Such rapid growth has not been recorded in the history of civilization before. Not long ago aluminium was sold at the fanciful price of thirty or forty dollars per pound; to-day it can be had in any desired amount for as many cents. What is more, the time is not far off when this price, too, will be considered fanciful, for great improvements are possible in the methods of its manufacture. Most of the metal is now produced in the electric furnace by a process combining fusion and electrolysis, which offers a number of advantageous features, but involves naturally a great waste of the electrical energy of the current. My estimates show that the price of aluminium could be considerably reduced by adopting in its manufacture a method similar to that proposed by me for the production of iron. A pound of aluminium requires for fusion only about seventy per cent. of the heat needed for melting a pound of iron, and inasmuch as its weight is only about one third of that of the latter, a volume of aluminium four times that of iron could be obtained from a given amount of heat-energy. But a cold electrolytic process of manufacture is the ideal solution, and on this I have placed my hope.

The absolutely unavoidable consequence of the advance of the aluminium industry will be the annihilation of the copper industry. They cannot exist and prosper together, and the latter is doomed beyond any hope of recovery. Even now it is cheaper to convey an electric current through aluminium wires than through copper wires; aluminium castings cost less, and in many domestic and other uses copper has no chance of successfully competing. A further material reduction of the price of aluminium cannot but be fatal to copper. But the progress of the former will not go on unchecked, for, as it ever happens in such cases, the larger industry will absorb the smaller one: the giant copper interests will control the pygmy aluminium interests, and the slow-pacing copper will reduce the lively gait of aluminium. This will only delay, not avoid, the impending catastrophe.

Aluminium, however, will not stop at downing copper. Before many years have passed it will be engaged in a fierce struggle with iron, and in the latter it will find an adversary not easy to conquer. The issue of the contest will largely depend on whether iron shall be indispensable in electric machinery. This the future alone can decide. The magnetism as exhibited in iron is an isolated phenomenon in nature. What it is that makes this metal behave so radically different from all other materials in this respect has not yet been ascertained, though many theories have been suggested. As regards magnetism, the molecules of the various bodies behave like hollow beams partly filled with a heavy fluid and balanced in the middle in the manner of a see-saw. Evidently some disturbing influence exists in nature which causes each molecule, like such a beam, to tilt either one or the other way. If the molecules are tilted one way, the body is magnetic; if they are tilted the other way, the body is non-magnetic; but both positions are stable, as they would be in the case of the hollow beam, owing to the rushing of the fluid to the lower end. Now, the wonderful thing is that the molecules of all known bodies went one way, while those of iron went the other way. This metal, it would seem, has an origin entirely different from that of the rest of the globe. It is highly improbable that we shall discover some other and cheaper material which will equal or surpass iron in magnetic qualities.

Unless we should make a radical departure in the character of the electric currents employed, iron will be indispensable. Yet

the advantages it offers are only apparent. So long as we use feeble magnetic forces it is by far superior to any other material; but if we find ways of producing great magnetic forces, then better results will be obtainable without it. In fact, I have already produced electric transformers in which no iron is employed, and which are capable of performing ten times as much work per pound of weight as those with iron. This result is attained by using electric currents of a very high rate of vibration, produced in novel ways, instead of the ordinary currents now employed in the industries. I have also succeeded in operating electric motors without iron by such rapidly vibrating currents, but the results, so far, have been inferior to those obtained with ordinary motors constructed of iron, although theoretically the former should be capable of performing incomparably more work per unit of weight than the latter. But the seemingly insuperable difficulties which are now in the way may be overcome in the end, and then iron will be done away with, and all electric machinery will be manufactured of aluminium, in all probability, at prices ridiculously low. This would be a severe, if not a fatal, blow to iron. In many other branches of industry, as ship-building, or wherever lightness of structure is required, the progress of the new metal will be much quicker. For such uses it is eminently suitable, and is sure to supersede iron sooner or later. It is highly probable that in the course of time we shall be able to give it many of those qualities which make iron so valuable.

While it is impossible to tell when this industrial revolution will be consummated, there can be no doubt that the future belongs to aluminium, and that in times to come it will be the chief means of increasing human performance. It has in this respect capacities greater by far than those of any other metal. I should estimate its civilizing potency at fully one hundred times that of iron. This estimate, though it may astonish, is not at all exaggerated. First of all, we must remember that there is thirty times as much aluminium as iron in bulk, available for the uses of man. This in itself offers great possibilities. Then, again, the new metal is much more easily workable, which adds to its value. In many of its properties it partakes of the character of a precious metal, which gives it additional worth. Its electric conductivity, which, for a given weight, is greater than that of any other metal, would be alone sufficient to make it one of the most important factors in future human progress. Its extreme lightness makes it far more easy to transport the objects manufactured. By virtue of this property it will revolutionize naval construction, and in facilitating transport and travel it will add enormously to the useful performance of mankind. But its greatest civilizing potency will be, I believe, in aërial travel, which is sure to be brought about by means of it. Telegraphic instruments will slowly enlighten the barbarian. Electric motors and lamps will do it more quickly, but quicker than anything else the flying-machine will do it. By rendering travel ideally easy it will be the best means for unifying the heterogeneous elements of humanity. As the first step toward this realization we should produce a lighter storage-battery or get more energy from coal.

EFFORTS TOWARD OBTAINING MORE ENERGY FROM COAL—THE ELECTRIC TRANSMISSION—THE GAS-ENGINE—THE COLD-COAL BATTERY.

I REMEMBER that at one time I considered the production of electricity by burning coal in a battery as the greatest achievement toward advancing civilization, and I am surprised to find how much the continuous study of these subjects has modified my views. It now seems to me that to burn coal, however efficiently, in a battery would be a mere makeshift, a phase in the evolution toward something much more perfect. After all, in generating electricity in this manner, we should be destroying material, and this would be a barbarous process. We ought to be able to obtain the energy we need without consumption of material. But I am far from underrating the value of such an efficient method of burning fuel. At the present time most motive power comes from coal, and, either directly or by its products, it adds vastly to human energy. Unfortunately, in all the processes now adopted, the larger portion of the energy of the coal is uselessly dissipated. The best steam-engines utilize only a small part of the total energy. Even in gas-engines, in which, particularly of late, better results are obtainable, there is still a barbarous waste going on. In our electric-lighting systems we scarcely utilize one third of one per cent., and in lighting by gas a much smaller fraction, of the total energy of the coal. Considering the various uses of coal throughout the world, we certainly do not utilize more than two per cent. of its energy theoretically available. The man who should stop this senseless waste would be a great

benefactor of humanity, though the solution he would offer could not be a permanent one, since it would ultimately lead to the exhaustion of the store of material. Efforts toward obtaining more energy from coal are now being made chiefly in two directions—by generating electricity and by producing gas for motive-power purposes. In both of these lines notable success has already been achieved.

The advent of the alternating-current system of electric power-transmission marks an epoch in the economy of energy available to man from coal. Evidently all electrical energy obtained from a waterfall, saving so much fuel, is a net gain to mankind, which is all the more effective as it is secured with little expenditure of human effort, and as this most perfect of all known methods of deriving energy from the sun contributes in many ways to the advancement of civilization. But electricity enables us also to get from coal much more energy than was practicable in the old ways. Instead of transporting the coal to distant places of consumption, we burn it near the mine, develop electricity in the dynamos, and transmit the current to remote localities, thus effecting a considerable saving. Instead of driving the machinery in a factory in the old wasteful way by belts and shafting, we generate electricity by steam-power and operate electric motors. In this manner it is not uncommon to obtain two or three times as much effective motive power from the fuel, besides securing many other important advantages. It is in this field as much as in the transmission of energy to great distances that the alternating system, with its ideally simple machinery, is bringing about an industrial revolution. But in many lines this progress has not yet been felt. For example, steamers and trains are still being propelled by the direct application of steam-power to shafts or axles. A much greater percentage of the heat-energy of the fuel could be transformed in motive energy by using, in place of the adopted marine engines and locomotives, dynamos driven by specially designed high-pressure steam- or gas-engines and by utilizing the electricity generated for the propulsion. A gain of fifty to one hundred per cent. in the effective energy derived from the coal could be secured in this manner. It is difficult to understand why a fact so plain and obvious is not receiving more attention from engineers. In ocean steamers such an improvement would be particularly desirable, as it would do away with noise and increase materially the speed and the carrying capacity of the liners.

Still more energy is now being obtained from coal by the latest improved gas-engine, the economy of which is, on the average, probably twice that of the best steam-engine. The introduction of the gas-engine is very much facilitated by the importance of the gas industry. With the increasing use of the electric light more and more of the gas is utilized for heating and motive-power purposes. In many instances gas is manufactured close to the coal-mine and conveyed to distant places of consumption, a considerable saving both in the cost of transportation and in utilization of the energy of the fuel being thus effected. In the present state of the mechanical and electrical arts the most rational way of deriving energy from coal is evidently to manufacture gas close to the coal store, and to utilize it, either on the spot or elsewhere, to generate electricity for industrial uses in dynamos driven by gas-engines. The commercial success of such a plant is largely dependent upon the production of gas-engines of great nominal horse-power, which, judging from the keen activity in this field, will soon be forthcoming. Instead of consuming coal directly, as usual, gas should be manufactured from it and burned to economize energy.

But all such improvements cannot be more than passing phases in the evolution toward something far more perfect, for ultimately we must succeed in obtaining electricity from coal in a more direct way, involving no great loss of its heat-energy. Whether coal can be oxidized by a cold process is still a question. Its combination with oxygen always evolves heat, and whether the energy of the combination of the carbon with another element can be turned directly into electrical energy has not yet been determined. Under certain conditions nitric acid will burn the carbon, generating an electric current, but the solution does not remain cold. Other means of oxidizing coal have been proposed, but they have offered no promise of leading to an efficient process. My own lack of success has been complete, though perhaps not quite so complete as that of some who have "perfected" the cold-coal battery. This problem is essentially one for the chemist to solve. It is not for the physicist, who determines all his results in advance, so that, when the experiment is tried, it cannot fail. Chemistry, though a positive science, does not yet admit of a solution by

such positive methods as those which are available in the treatment of many physical problems. The result, if possible, will be arrived at through patient trying rather than through deduction or calculation. The time will soon come, however, when the chemist will be able to follow a course clearly mapped out beforehand, and when the process of his arriving at a desired result will be purely constructive. The cold-coal battery would give a great impetus to electrical development; it would lead very shortly to a practical flying-machine, and would enormously enhance the introduction of the automobile. But these and many other problems will be better solved, and in a more scientific manner, by a light-storage battery.

ENERGY FROM THE MEDIUM—THE WINDMILL AND THE SOLAR ENGINE—MOTIVE POWER FROM TERRESTRIAL HEAT—ELECTRICITY FROM NATURAL SOURCES.

BESIDES fuel, there is abundant material from which we might eventually derive power. An immense amount of energy is locked up in limestone, for instance, and machines can be driven by liberating the carbonic acid through sulphuric acid or otherwise. I once constructed such an engine, and it operated satisfactorily.

But, whatever our resources of primary energy may be in the future, we must, to be rational, obtain it without consumption of any material. Long ago I came to this conclusion, and to arrive at this result only two ways, as before indicated, appeared possible—either to turn to use the energy of the sun stored in the ambient medium, or to transmit, through the medium, the sun's energy to distant places from some locality where it was obtainable without consumption of material. At that time I at once rejected the latter method as entirely impracticable, and turned to examine the possibilities of the former.

It is difficult to believe, but it is, nevertheless, a fact, that since time immemorial man has had at his disposal a fairly good machine which has enabled him to utilize the energy of the ambient medium. This machine is the windmill. Contrary to popular belief, the power obtainable from wind is very considerable. Many a deluded inventor has spent years of his life in endeavoring to "harness the tides," and some have even proposed to compress air by tide- or wave-power for supplying energy, never understanding the signs of the old windmill on the hill, as it sorrowfully waved its arms about and bade them stop. The fact is that a wave- or tide-motor would have, as a rule, but a small chance of competing commercially with the windmill, which is by far the better machine, allowing a much greater amount of energy to be obtained in a simpler way. Wind-power has been, in old times, of inestimable value to man, if for nothing else but for enabling him to cross the seas, and it is even now a very important factor in travel and transportation. But there are great limitations in this ideally simple method of utilizing the sun's energy. The machines are large for a given output, and the power is intermittent, thus necessitating the storage of energy and increasing the cost of the plant.

A far better way, however, to obtain power would be to avail ourselves of the sun's rays, which beat the earth incessantly and supply energy at a maximum rate of over four million horse-power per square mile. Although the average energy received per square mile in any locality during the year is only a small fraction of that amount, yet an inexhaustible source of power would be opened up by the discovery of some efficient method of utilizing the energy of the rays. The only rational way known to me at the time when I began the study of this subject was to employ some kind of heat- or thermodynamic engine, driven by a volatile fluid evaporated in a boiler by the heat of the rays. But closer investigation of this method, and calculation, showed that, notwithstanding the apparently vast amount of energy received from the sun's rays, only a small fraction of that energy could be actually utilized in this manner. Furthermore, the energy supplied through the sun's radiations is periodical, and the same limitations as in the use of the windmill I found to exist here also. After a long study of this mode of obtaining motive power from the sun, taking into account the necessarily large bulk of the boiler, the low efficiency of the heat-engine, the additional cost of storing the energy, and other drawbacks, I came to the conclusion that the "solar engine," a few instances excepted, could not be industrially exploited with success.

Another way of getting motive power from the medium without consuming any material would be to utilize the heat contained in the earth, the water, or the air for driving an engine. It is a well-known fact that the interior portions of the globe are very hot, the temperature rising, as observa-

tions show, with the approach to the center at the rate of approximately 1° C. for every hundred feet of depth. The difficulties of sinking shafts and placing boilers at depths of, say, twelve thousand feet, corresponding to an increase in temperature of about 120° C., are not insuperable, and we could certainly avail ourselves in this way of the internal heat of the globe. In fact, it would not be necessary to go to any depth at all in order to derive energy from the stored terrestrial heat. The superficial layers of the earth and the air strata close to the same are at a temperature sufficiently high to evaporate some extremely volatile substances, which we might use in our boilers instead of water. There is no doubt that a vessel might be propelled on the ocean by an engine driven by such a volatile fluid, no other energy being used but the heat abstracted from the water. But the amount of power which could be obtained in this manner would be, without further provision, very small.

Electricity produced by natural causes is another source of energy which might be rendered available. Lightning discharges involve great amounts of electrical energy, which we could utilize by transforming and storing it. Some years ago I made known a method of electrical transformation which renders the first part of this task easy, but the storing of the energy of lightning discharges will be difficult to accomplish. It is well known, furthermore, that electric currents circulate constantly through the earth, and that there exists between the earth and any air stratum a difference of electrical pressure, which varies in proportion to the height.

In recent experiments I have discovered two novel facts of importance in this connection. One of these facts is that an electric current is generated in a wire extending from the ground to a great height by the axial, and probably also by the translatory, movement of the earth. No appreciable current, however, will flow continuously in the wire unless the electricity is allowed to leak out into the air. Its escape is greatly facilitated by providing at the elevated end of the wire a conducting terminal of great surface, with many sharp edges or points. We are thus enabled to get a continuous supply of electrical energy by merely supporting a wire at a height, but, unfortunately, the amount of electricity which can be so obtained is small.

The second fact which I have ascertained is that the upper air strata are permanently charged with electricity opposite to that of the earth. So, at least, I have interpreted my observations, from which it appears that the earth, with its adjacent insulating and outer conducting envelop, constitutes a highly charged electrical condenser containing, in all probability, a great amount of electrical energy which might be turned to the uses of man, if it were possible to reach with a wire to great altitudes.

It is possible, and even probable, that there will be, in time, other resources of energy opened up, of which we have no knowledge now. We may even find ways of applying forces such as magnetism or gravity for driving machinery without using any other means. Such realizations, though highly improbable, are not impossible. An example will best convey an idea of what we can hope to attain and what we can never attain. Imagine a disk of some homogeneous material turned perfectly true and arranged to turn in frictionless bearings on a horizontal shaft above the ground. This disk, being under the above conditions perfectly balanced, would rest in any position. Now, it is possible that we may learn how to make such a disk rotate continuously and perform work by the force of gravity without any further effort on our part; but it is perfectly impossible for the disk to turn and to do work without any force from the outside. If it could do so, it would be what is designated scientifically as a "perpetuum mobile," a machine creating its own motive power. To make the disk rotate by the force of gravity we have only to invent a screen against this force. By such a screen we could prevent this force from acting on one half of the disk, and the rotation of the latter would follow. At least, we cannot deny such a possibility until we know exactly the nature of the force of gravity. Suppose that this force were due to a movement comparable to that of a stream of air passing from above toward the center of the earth. The effect of such a stream upon both halves of the disk would be equal, and the latter would not rotate ordinarily; but if one half should be guarded by a plate arresting the movement, then it would turn.

A DEPARTURE FROM KNOWN METHODS—POSSIBILITY OF A "SELF-ACTING" ENGINE OR MACHINE, INANIMATE, YET CAPABLE, LIKE A LIVING BEING, OF DERIVING ENERGY FROM THE MEDIUM—THE IDEAL WAY OF OBTAINING MOTIVE POWER.

WHEN I began the investigation of the subject under consideration, and when the preceding or similar ideas presented themselves

to me for the first time, though I was then unacquainted with a number of the facts mentioned, a survey of the various ways of utilizing the energy of the medium convinced me, nevertheless, that to arrive at a thoroughly satisfactory practical solution a radical departure from the methods then known had to be made. The windmill, the solar engine, the engine driven by terrestrial heat, had their limitations in the amount of power obtainable. Some new way had to be discovered which would enable us to get more energy. There was enough heat-energy in the medium, but only a small part of it was available for the operation of an engine in the ways then known. Besides, the energy was obtainable only at a very slow rate. Clearly, then, the problem was to discover some new method which would make it possible both to utilize more of the heat-energy of the medium and also to draw it away from the same at a more rapid rate.

I was vainly endeavoring to form an idea of how this might be accomplished, when I read some statements from Carnot and Lord Kelvin (then Sir William Thomson) which meant virtually that it is impossible for an inanimate mechanism or self-acting machine to cool a portion of the medium below the temperature of the surrounding, and operate by the heat abstracted. These statements interested me intensely. Evidently a living being could do this very thing, and since the experiences of my early life which I have related had convinced me that a living being is only an automaton, or, otherwise stated, a "self-acting engine," I came to the conclusion that it was possible to construct a machine which would do the same. As the first step toward this realization I conceived the following mechanism. Imagine a thermopile consisting of a number of bars of metal extending from the earth to the outer space beyond the atmosphere. The heat from below, conducted upward along these metal bars, would cool the earth or the sea or the air, according to the location of the lower parts of the bars, and the result, as is well known, would be an electric current circulating in these bars. The two terminals of the thermopile could now be joined through an electric motor, and, theoretically, this motor would run on and on, until the media below would be cooled down to the temperature of the outer space. This would be an inanimate engine which, to all evidence, would be cooling a portion of the medium below the temperature of the surrounding, and operating by the heat abstracted.

But was it not possible to realize a similar condition without necessarily going to a height? Conceive, for the sake of illustration, an inclosure *T*, as illustrated in diagram *b*, such that energy could not be transferred across it except through a channel or path *O*, and that, by some means or other, in this inclosure a medium were maintained which would have little energy, and that on the outer side of the same there would be the ordinary ambient medium with much energy. Under these assumptions the energy would flow through the path *O*, as indicated by the arrow, and might then be converted on its passage into some other form of energy. The question was, Could such a condition be attained? Could we produce artificially such a "sink" for the energy of the ambient medium to flow in? Suppose that an extremely low temperature could be maintained by some process in a given space; the surrounding medium would then be compelled to give off heat, which could be converted into mechanical or other form of energy, and utilized. By realizing such a plan, we should be enabled to get at any point of the globe a continuous supply of energy, day and night. More than this, reasoning in the abstract, it would seem possible to cause a quick circulation of the medium, and thus draw the energy at a very rapid rate.

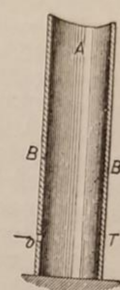


DIAGRAM *b*. OBTAINING ENERGY FROM THE AMBIENT MEDIUM.

A, medium with little energy; *B, B*, ambient medium with much energy; *O*, path of the energy.

Here, then, was an idea which, if realizable, afforded a happy solution of the problem of getting energy from the medium. But was it realizable? I convinced myself that it was so in a number of ways, of which one is the following. As regards heat, we are at a high level, which may be represented by the surface of a mountain lake considerably above the sea, the level of which may mark the absolute zero of temperature existing in the interstellar space. Heat, like water, flows

from high to low level, and, consequently, just as we can let the water of the lake run down to the sea, so we are able to let heat from the earth's surface travel up into the cold region above. Heat, like water, can perform work in flowing down, and if we had any doubt as to whether we could derive energy from the medium by means of a thermopile, as before described, it would be dispelled by this analogue. But can we produce cold in a given portion of the space and cause the heat to flow in continually? To create such a "sink," or "cold hole," as we might say, in the medium, would be equivalent to producing in the lake a space either empty or filled with something much lighter than water. This we could do by placing in the lake a tank, and pumping all the water out of the latter. We know, then, that the water, if allowed to flow back into the tank, would, theoretically, be able to perform exactly the same amount of work which was used in pumping it out, but not a bit more. Consequently nothing could be gained in this double operation of first raising the water and then letting it fall down. This would mean that it is impossible to create such a sink in the medium. But let us reflect a moment. Heat, though following certain general laws of mechanics, like a fluid, is not such; it is energy which may be converted into other forms of energy as it passes from a high to a low level. To make our mechanical analogy complete and true, we must, therefore, assume that the water, in its passage into the tank, is converted into something else, which may be taken out of it without using any, or by using very little, power. For example, if heat be represented in this analogue by the water of the lake, the oxygen and hydrogen composing the water may illustrate other forms of energy into which the heat is transformed in passing from hot to cold. If the process of heat-transformation were absolutely perfect, no heat at all would arrive at the low level, since all of it would be converted into other forms of energy. Corresponding to this ideal case, all the water flowing into the tank would be decomposed into oxygen and hydrogen before reaching the bottom, and the result would be that water would continually flow in, and yet the tank would remain entirely empty, the gases formed escaping. We would thus produce, by expending initially a certain amount of work to create a sink for the heat or, respectively, the water to flow in, a condition enabling us to get any amount of energy without further effort. This would be an ideal way of obtaining motive power. We do not know of any such absolutely perfect process of heat-conversion, and consequently some heat will generally reach the low level, which means to say, in our mechanical analogue, that some water will arrive at the bottom of the tank, and a gradual and slow filling of the latter will take place, necessitating continuous pumping out. But evidently there will be less to pump out than flows in, or, in other words, less energy will be needed to maintain the initial condition than is developed by the fall, and this is to say that some energy will be gained from the medium. What is not converted in flowing down can just be raised up with its own energy, and what is converted is clear gain. Thus the virtue of the principle I have discovered resides wholly in the conversion of the energy on the downward flow.

FIRST EFFORTS TO PRODUCE THE SELF-ACTING ENGINE—THE MECHANICAL OSCILLATOR—WORK OF DEWAR AND LINDE—LIQUID AIR.

HAVING recognized this truth, I began to devise means for carrying out my idea, and, after long thought, I finally conceived a combination of apparatus which should make possible the obtaining of power from the medium by a process of continuous cooling of atmospheric air. This apparatus, by continually transforming heat into mechanical work, tended to become colder and colder, and if it only were practicable to reach a very low temperature in this manner, then a sink for the heat could be produced, and energy could be derived from the medium. This seemed to be contrary to the statements of Carnot and Lord Kelvin before referred to, but I concluded from the theory of the process that such a result could be attained. This conclusion I reached, I think, in the latter part of 1883, when I was in Paris, and it was at a time when my mind was being more and more dominated by an invention which I had evolved during the preceding year, and which has since become known under the name of the "rotating magnetic field." During the few years which followed I elaborated further the plan I had imagined, and studied the working conditions, but made little headway. The commercial introduction in this country of the invention before referred to required most of my energies until 1889, when I again took up the idea of the self-acting machine. A closer in-

vestigation of the principles involved, and calculation, now showed that the result I aimed at could not be reached in a practical manner by ordinary machinery, as I had in the beginning expected. This led me, as a next step, to the study of a type of engine generally designated as "turbine," which at first seemed to offer better chances for a realization of the idea. Soon I found, however, that the turbine, too, was unsuitable. But my conclusions showed that if an engine of a peculiar kind could be brought to a high degree of perfection, the plan I had conceived was realizable, and I resolved to proceed with the development of such an engine, the primary object of which was to secure the greatest economy of transformation of heat into mechanical energy. A characteristic feature of the engine was that the work-performing piston was not connected with anything else, but was perfectly free to vibrate at an enormous rate. The mechanical difficulties encountered in the construction of this engine were greater than I had anticipated, and I made slow progress. This work was continued until early in 1892, when I went to London, where I saw Professor Dewar's admirable experiments with liquefied gases. Others had liquefied gases before, and notably Ozlewski and Pictet had performed creditable early experiments in this line, but there was such a vigor about the work of Dewar that even the old appeared new. His experiments showed, though in a way different from that I had imagined, that it was possible to reach a very low temperature by transforming heat into mechanical work, and I returned, deeply impressed with what I had seen, and more than ever convinced that my plan was practicable. The work temporarily interrupted was taken up anew, and soon I had in a fair state of perfection the engine which I have named "the mechanical oscillator." In this machine I succeeded in doing away with all packings, valves, and lubrication, and in producing so rapid a vibration of the piston that shafts of tough steel, fastened to the same and vibrated longitudinally, were torn asunder. By combining this engine with a dynamo of special design I produced a highly efficient electrical generator, invaluable in measurements and determinations of physical quantities on account of the unvarying rate of oscillation obtainable by its means. I exhibited several types of this machine, named "mechanical and electrical oscillator," before the Electrical Congress at the World's Fair in Chicago during the summer of 1893, in a lecture which, on account of other pressing work, I was unable to prepare for publication. On that occasion I exposed the principles of the mechanical oscillator, but the original purpose of this machine is explained here for the first time.

In the process, as I had primarily conceived it, for the utilization of the energy of the ambient medium, there were five essential elements in combination, and each of these had to be newly designed and perfected, as no such machines existed. The mechanical oscillator was the first element of this combination, and having perfected this, I turned to the next, which was an air-compressor of a design in certain respects resembling that of the mechanical oscillator. Similar difficulties in the construction were again encountered, but the work was pushed vigorously, and at the close of 1894 I had completed these two elements of the combination, and thus produced an apparatus for compressing air, virtually to any desired pressure, incomparably simpler, smaller, and more efficient than the ordinary. I was just beginning work on the third element, which together with the first two would give a refrigerating machine of exceptional efficiency and simplicity, when a misfortune befell me in the burning of my laboratory, which crippled my labors and delayed me. Shortly afterward Dr. Carl Linde announced the liquefaction of air by a self-cooling process, demonstrating that it was practicable to proceed with the cooling until liquefaction of the air took place. This was the only experimental proof which I was still wanting that energy was obtainable from the medium in the manner contemplated by me.

The liquefaction of air by a self-cooling process was not, as popularly believed, an accidental discovery, but a scientific result which could not have been delayed much longer, and which, in all probability, could not have escaped Dewar. This fascinating advance, I believe, is largely due to the powerful work of this great Scotchman. Nevertheless, Linde's is an immortal achievement. The manufacture of liquid air has been carried on for four years in Germany, on a scale much larger than in any other country, and this strange product has been applied for a variety of purposes. Much was expected of it in the beginning, but so far it has been an industrial ignis fatuus. By the use of such machinery as I am perfecting, its cost will probably be greatly lessened, but even then its commercial success will be ques-

tionable. When used as a refrigerant it is uneconomical, as its temperature is unnecessarily low. It is as expensive to maintain a body at a very low temperature as it is to keep it very hot; it takes coal to keep air cold. In oxygen manufacture it cannot yet compete with the electrolytic method. For use as an explosive it is unsuitable, because its low temperature again condemns it to a small efficiency, and for motive-power purposes its cost is still by far too high. It is of interest to note, however, that in driving an engine by liquid air a certain amount of energy may be gained from the engine, or, stated otherwise, from the ambient medium which keeps the engine warm, each two hundred pounds of iron-casting of the latter contributing energy at the rate of about one effective horse-power during one hour. But this gain of the consumer is offset by an equal loss of the producer.

Much of this task on which I have labored so long remains to be done. A number of mechanical details are still to be perfected and some difficulties of a different nature to be mastered, and I cannot hope to produce a self-acting machine deriving energy from the ambient medium for a long time yet, even if all my expectations should materialize. Many circumstances have occurred which have retarded my work of late, but for several reasons the delay was beneficial.

One of these reasons was that I had ample time to consider what the ultimate possibilities of this development might be. I worked for a long time fully convinced that the practical realization of this method of obtaining energy from the sun would be of incalculable industrial value, but the continued study of the subject revealed the fact that while it will be commercially profitable if my expectations are well founded, it will not be so to an extraordinary degree.

DISCOVERY OF UNEXPECTED PROPERTIES OF THE ATMOSPHERE—STRANGE EXPERIMENTS—TRANSMISSION OF ELECTRICAL ENERGY THROUGH ONE WIRE WITHOUT RETURN—TRANSMISSION THROUGH THE EARTH WITHOUT ANY WIRE.

ANOTHER of these reasons was that I was led to recognize the transmission of electrical energy to any distance through the media as by far the best solution of the great problem of harnessing the sun's energy for the uses of man. For a long time I was convinced that such a transmission on an industrial scale could never be realized, but a discovery which I made changed my view. I observed that under certain conditions the atmosphere, which is normally a high insulator, assumes conducting properties, and so becomes capable of conveying any amount of electrical energy. But the difficulties in the way of a practical utilization of this discovery for the purpose of transmitting electrical energy without wires were seemingly insuperable. Electrical pressures of many millions of volts had to be produced and handled; generating apparatus of a novel kind, capable of withstanding the immense electrical stresses, had to be invented and perfected, and a complete safety against the dangers of the high-tension currents had to be attained in the system before its practical introduction could be even thought of. All this could not be done in a few weeks or months, or even years. The work required patience and constant application, but the improvements came, though slowly. Other valuable results were, however, arrived at in the course of this long-continued work, of which I shall endeavor to give a brief account, enumerating the chief advances as they were successively effected.

The discovery of the conducting properties of the air, though unexpected, was only a natural result of experiments in a special field which I had carried on for some years before. It was, I believe, during 1889 that certain possibilities offered by extremely rapid electrical oscillations determined me to design a number of special machines adapted for their investigation. Owing to the peculiar requirements, the construction of these machines was very difficult, and consumed much time and effort; but my work on them was generously rewarded, for I reached by their means several novel and important results. One of the earliest observations I made with these new machines was that electrical oscillations of an extremely high rate act in an extraordinary manner upon the human organism. Thus, for instance, I demonstrated that powerful electrical discharges of several hundred thousand volts, which at that time were considered absolutely deadly, could be passed through the body without inconvenience or hurtful consequences. These oscillations produced other specific physiological effects, which, upon my announcement, were eagerly taken up by skilled physicians and further investigated. This new field has proved itself fruitful beyond expectation, and in the few years which have passed since, it has been

developed to such an extent that it now forms a legitimate and important department of medical science. Many results, thought impossible at that time, are now readily obtainable with these oscillations, and many experiments undreamed of then can now be readily performed by their means. I still remember with pleasure how, nine years ago, I passed the discharge of a powerful induction-coil through my body to demonstrate before a scientific society the comparative harmlessness of very rapidly vibrating electric currents, and I can still recall the astonishment of my audience. I would now undertake, with much less apprehension than I had in that experiment, to transmit through my body with such currents the entire electrical energy of the dynamos now working at Niagara—forty or fifty thousand horse-power. I have produced electrical oscillations which were of such intensity that when circulating through my arms and chest they have melted wires which joined my hands, and still I felt no inconvenience. I have energized with such oscillations a loop of heavy copper wire so powerfully that masses of metal, and even objects of an electrical resistance specifically greater than that of human tissue, brought close to or placed within the loop, were heated to a high temperature and melted, often with the violence of an explosion, and yet into this very space in which this terribly destructive turmoil was going on I have repeatedly thrust my head without feeling anything or experiencing injurious after-effects.

Another observation was that by means of such oscillations light could be produced in a novel and more economical manner, which promised to lead to an ideal system of electric illumination by vacuum-tubes, dispensing with the necessity of renewal of lamps or incandescent filaments, and possibly also with the use of wires in the interior of buildings. The efficiency of this light increases in proportion to the rate of the oscillations, and its commercial success is, therefore, dependent on the economical production of electrical vibrations of transcending rates. In this direction I have met with gratifying success of late, and the practical introduction of this new system of illumination is not far off.

The investigations led to many other valuable observations and results, one of the more important of which was the demonstration of the practicability of supplying electrical energy through one wire without return. At first I was able to transmit in this novel manner only very small amounts of electrical energy, but in this line also my efforts have been rewarded with similar success.

The photograph shown in Fig. 3 (see p. 186) illustrates, as its title explains, an actual transmission of this kind effected with apparatus used in other experiments here described. To what a degree the appliances have been perfected since my first demonstrations early in 1891 before a scientific society, when my apparatus was barely capable of lighting one lamp (which result was considered wonderful), will appear when I state that I have now no difficulty in lighting in this manner four or five hundred lamps, and could light many more. In fact, there is no limit to the amount of energy which may in this way be supplied to operate any kind of electrical device.

After demonstrating the practicability of this method of transmission, the thought naturally occurred to me to use the earth as a conductor, thus dispensing with all wires. Whatever electricity may be, it is a fact that it behaves like an incompressible fluid, and the earth may be looked upon as an immense reservoir of electricity, which, I thought, could be disturbed effectively by a properly designed electrical machine. Accordingly, my next efforts were directed toward perfecting a special apparatus which would be highly effective in creating a disturbance of electricity in the earth. The progress in this new direction was necessarily very slow and the work discouraging, until I finally succeeded in perfecting a novel kind of transformer or induction-coil, particularly suited for this special purpose. That it is practicable, in this manner, not only to transmit minute amounts of electrical energy for operating delicate electrical devices, as I contemplated at first, but also electrical energy in appreciable quantities, will appear from an inspection of Fig. 4 (see p. 186), which illustrates an actual experiment of this kind performed with the same apparatus. The result obtained was all the more remarkable as the top end of the coil was not connected to a wire or plate for magnifying the effect.

"WIRELESS" TELEGRAPHY—THE SECRET OF TUNING—ERRORS IN THE HERTZIAN INVESTIGATIONS—A RECEIVER OF WONDERFUL SENSITIVENESS.

As the first valuable result of my experiments in this latter line a system of telegraphy without wires resulted, which I described in two

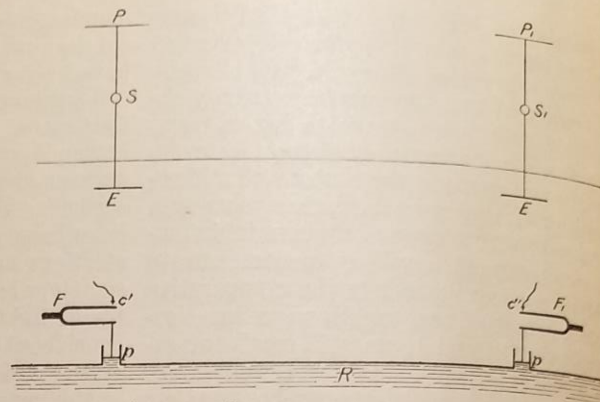


DIAGRAM c. "WIRELESS" TELEGRAPHY MECHANICALLY ILLUSTRATED.

scientific lectures in February and March, 1893. It is mechanically illustrated in diagram *c*, the upper part of which shows the electrical arrangement as I described it then, while the lower part illustrates its mechanical analogue. The system is extremely simple in principle. Imagine two tuning-forks F, $F_{,}$, one at the sending- and the other at the receiving-station respectively, each having attached to its lower prong a minute piston p, fitting in a cylinder. Both the cylinders communicate with a large reservoir R, with elastic walls, which is supposed to be closed and filled with a light and incompressible fluid. By striking repeatedly one of the prongs of the tuning-fork F, the small piston p below would be vibrated, and its vibrations, transmitted through the fluid, would reach the distant fork $F_{,}$, which is "tuned" to the fork F, or, stated otherwise, of exactly the same note as the latter. The fork $F_{,}$ would now be set vibrating, and its vibration would be intensified by the continued action of the distant fork F until its upper prong, swinging far out, would make an electrical connection with a stationary contact c'', starting in this manner some electrical or other appliances which may be used for recording the signals. In this simple way messages could be exchanged between the two stations, a similar contact c' being provided for this purpose, close to the upper prong of the fork F, so that the apparatus at each station could be employed in turn as receiver and transmitter.

The electrical system illustrated in the upper figure of diagram *c* is exactly the same in principle, the two wires or circuits ESP and $E_{,}S_{,}P_{,}$, which extend vertically to a height, representing the two tuning-forks with the pistons attached to them. These circuits are connected with the ground by plates E, $E_{,}$, and to two elevated metal sheets P, $P_{,}$, which store electricity and thus magnify considerably the effect. The closed reservoir R, with elastic walls, is in this case replaced by the earth, and the fluid by electricity. Both of these circuits are "tuned" and operate just like the two tuning-forks. Instead of striking the fork F at the sending-station, electrical oscillations are produced in the vertical sending- or transmitting-wire ESP, as by the action of a source S, included in this wire, which spread through the ground and reach the distant vertical receiving-wire $E_{,}S_{,}P_{,}$, exciting corresponding electrical oscillations in the same. In the latter wire or circuit is included a sensitive device or receiver $S_{,}$, which is thus set in action and made to operate a relay or other appliance. Each station is, of course, provided both with a source of electrical oscillations S and a sensitive receiver $S_{,}$, and a simple provision is made for using each of the two wires alternately to send and to receive the messages.

The exact attunement of the two circuits secures great advantages, and, in fact, it is essential in the practical use of the system. In this respect many popular errors exist, and, as a rule, in the technical reports on this subject circuits and appliances are described as affording these advantages when from their very nature it is evident that this is impossible. In order to attain the best results it is essential that the length of each wire or circuit, from the ground connection to the top, should be equal to one quarter of the wave-length of the electrical vibration in the wire, or else equal to that length multiplied by an odd number. Without the observation of this rule it is virtually impossible to prevent the interference and insure the privacy of messages. Therein lies the secret of tuning. To obtain the most satisfactory results it is, however, necessary to resort to electrical vibrations of low pitch. The Hertzian spark apparatus, used generally by experimenters, which produces oscillations of a very high rate, permits no effective tuning, and slight disturbances are sufficient to render an exchange of messages impracticable. But scientifically designed, efficient appliances allow nearly perfect adjustment. An experiment performed with the improved apparatus repeatedly referred to, and intended to convey an idea of this feature, is

illustrated in Fig. 5 (p. 187), which is sufficiently explained by its note.

Since I described these simple principles of telegraphy without wires I have had frequent occasion to note that the identical features and elements have been used, in the evident belief that the signals are being transmitted to considerable distances by "Hertzian" radiations. This is only one of many misapprehensions to which the investigations of the lamented physicist have given rise. About thirty-three years ago Maxwell, following up a suggestive experiment made by Faraday in 1845, evolved an ideally simple theory which intimately connected light, radiant heat, and electrical phenomena, interpreting them as being all due to vibrations of a hypothetical fluid of inconceivable tenuity, called the ether. No experimental verification was arrived at until Hertz, at the suggestion of Helmholtz, undertook a series of experiments to this effect. Hertz proceeded with extraordinary ingenuity and insight, but devoted little energy to the perfection of his old-fashioned apparatus. The consequence was that he failed to observe the important function which the air played in his experiments, and which I subsequently discovered. Repeating his experiments and reaching different results, I ventured to point out this oversight. The strength of the proofs brought forward by Hertz in support of Maxwell's theory resided in the correct estimate of the rates of vibration of the circuits he used. But I ascertained that he could not have obtained the rates he thought he was getting. The vibrations with identical apparatus he employed are, as a rule, much slower, this being due to the presence of air, which produces a dampening effect upon a rapidly vibrating electric circuit of high pressure, as a fluid does upon a vibrating tuning-fork. I have, however, discovered since that time other causes of error, and I have long ago ceased to look upon his results as being an experimental verification of the poetical conceptions of Maxwell. The work of the great German physicist has acted as an immense stimulus to contemporary electrical research, but it has likewise, in a measure, by its fascination, paralyzed the scientific mind, and thus hampered independent inquiry. Every new phenomenon which was discovered was made to fit the theory, and so very often the truth has been unconsciously distorted.

When I advanced this system of telegraphy, my mind was dominated by the idea of effecting communication to any distance through the earth or environing medium, the practical consummation of which I considered of transcendent importance, chiefly on account of the moral effect which it could not fail to produce universally. As the first effort to this end I proposed, at that time, to employ relay-stations with tuned circuits, in the hope of making thus practicable signaling over vast distances, even with apparatus of very moderate power then at my command. I was confident, however, that with properly designed machinery signals could be transmitted to any point of the globe, no matter what the distance, without the necessity of using such intermediate stations. I gained this conviction through the discovery of a singular electrical phenomenon, which I described early in 1892, in lectures delivered before some scientific societies abroad, and which I have called a "rotating brush." This is a bundle of light which is formed, under certain conditions, in a vacuum-bulb, and which is of a sensitiveness to magnetic and electric influences bordering, so to speak, on the supernatural. This light-bundle is rapidly rotated by the earth's magnetism as many as twenty thousand times per second, the rotation in these parts being opposite to what it would be in the southern hemisphere, while in the region of the magnetic equator it should not rotate at all. In its most sensitive state, which is difficult to attain, it is responsive to electric or magnetic influences to an incredible degree. The mere stiffening of the muscles of the arm and consequent slight electrical change in the body of an observer standing at some distance from it, will perceptibly affect it. When in this highly sensitive state it is capable of indicating the slightest magnetic and electric changes taking place in the earth. The observation of this wonderful phenomenon impressed me strongly that communication at any distance could be easily effected by its means, provided that apparatus could be perfected capable of producing an electric or magnetic change of state, however small, in the terrestrial globe or environing medium.

DEVELOPMENT OF A NEW PRINCIPLE—THE ELECTRICAL OSCILLATOR—PRODUCTION OF IMMENSE ELECTRICAL MOVEMENTS—THE EARTH RESPONDS TO MAN—INTERPLANETARY COMMUNICATION NOW PROBABLE.

I RESOLVED to concentrate my efforts upon this venturesome task, though it involved

great sacrifice, for the difficulties to be mastered were such that I could hope to consummate it only after years of labor. It meant delay of other work to which I would have preferred to devote myself, but I gained the conviction that my energies could not be more usefully employed; for I recognized that an efficient apparatus for the production of powerful electrical oscillations, as was needed for that specific purpose, was the key to the solution of other most important electrical and, in fact, human problems. Not only was communication, to any distance, without wires possible by its means, but, likewise, the transmission of energy in great amounts, the burning of the atmospheric nitrogen, the production of an efficient illuminant, and many other results of inestimable scientific and industrial value. Finally, however, I had the satisfaction of accomplishing the task undertaken by the use of a new principle, the virtue of which is based on the marvelous properties of the electrical condenser. One of these is that it can discharge or explode its stored energy in an inconceivably short time. Owing to this it is unequaled in explosive violence. The explosion of dynamite is only the breath of a consumptive compared with its discharge. It is the means of producing the strongest current, the highest electrical pressure, the greatest commotion in the medium. Another of its properties, equally valuable, is that its discharge may vibrate at any rate desired up to many millions per second.

I had arrived at the limit of rates obtainable in other ways when the happy idea presented itself to me to resort to the condenser. I arranged such an instrument so as to be charged and discharged alternately in rapid succession through a coil with a few turns of stout wire, forming the primary of a transformer or induction-coil. Each time the condenser was discharged the current would quiver in the primary wire and induce corresponding oscillations in the secondary. Thus a transformer or induction-coil on new principles was evolved, which I have called "the electrical oscillator," partaking of those unique qualities which characterize the condenser, and enabling results to be attained impossible by other means. Electrical effects of any desired character and of intensities undreamed of before are now easily producible by perfected apparatus of this kind, to which frequent reference has been made, and the essential parts of which are shown in Fig. 6 (p. 188). For certain purposes a strong inductive effect is required; for others the greatest possible suddenness; for others again, an exceptionally high rate of vibration or extreme pressure; while for certain other objects immense electrical movements are necessary. The photographs in Figs. 7, 8, 9, and 10, of experiments performed with such an oscillator, may serve to illustrate some of these features and convey an idea of the magnitude of the effects actually produced. The completeness of the titles of the figures referred to makes a further description of them unnecessary.

However extraordinary the results shown may appear, they are but trifling compared with those which are attainable by apparatus designed on these same principles. I have produced electrical discharges the actual path of which, from end to end, was probably more than one hundred feet long; but it would not be difficult to reach lengths one hundred times as great. I have produced electrical movements occurring at the rate of approximately one hundred thousand horse-power, but rates of one, five, or ten million horse-power are easily practicable. In these experiments effects were developed incomparably greater than any ever produced by human agencies, and yet these results are but an embryo of what is to be.

That communication without wires to any point of the globe is practicable with such apparatus would need no demonstration, but through a discovery which I made I obtained absolute certitude. Popularly explained, it is exactly this: When we raise the voice and hear an echo in reply, we know that the sound of the voice must have reached a distant wall, or boundary, and must have been reflected from the same. Exactly as the sound, so an electrical wave is reflected, and the same evidence which is afforded by an echo is offered by an electrical phenomenon known as a "stationary" wave—that is, a wave with fixed nodal and ventral regions. Instead of sending sound-vibrations toward a distant wall, I have sent electrical vibrations toward the remote boundaries of the earth, and instead of the wall the earth has replied. In place of an echo I have obtained a stationary electrical wave, a wave reflected from afar.

Stationary waves in the earth mean something more than mere telegraphy without wires to any distance. They will enable us to attain many important specific results impossible otherwise. For instance, by their use we may produce at will, from a sending-station, an electrical effect in any particular

region of the globe; we may determine the relative position or course of a moving object, such as a vessel at sea, the distance traversed by the same, or its speed; or we may send over the earth a wave of electricity traveling at any rate we desire, from the pace of a turtle up to lightning speed.

With these developments we have every reason to anticipate that in a time not very distant most telegraphic messages across the oceans will be transmitted without cables. For short distances we need a "wireless" telephone, which requires no expert operators. The greater the spaces to be bridged, the more rational becomes communication without wires. The cable is not only an easily damaged and costly instrument, but it limits us in the speed of transmission by reason of a certain electrical property inseparable from its construction. A properly designed plant for effecting communication without wires ought to have many times the working capacity of a cable, while it will involve incomparably less expense. Not a long time will pass, I believe, before communication by cable will become obsolete, for not only will signaling by this new method be quicker and cheaper, but also much safer. By using some new means for isolating the messages which I have contrived, an almost perfect privacy can be secured.

I have observed the above effects so far only up to a limited distance of about six hundred miles, but inasmuch as there is virtually no limit to the power of the vibrations producible with such an oscillator, I feel quite confident of the success of such a plant for effecting transoceanic communication. Nor is this all. My measurements and calculations have shown that it is perfectly practicable to produce on our globe, by the use of these principles, an electrical movement of such magnitude that, without the slightest doubt, its effect will be perceptible on some of our nearer planets, as Venus and Mars. Thus from mere possibility interplanetary communication has entered the stage of probability. In fact, that we can produce a distinct effect on one of these planets in this novel manner, namely, by disturbing the electrical condition of the earth, is beyond any doubt. This way of effecting such communication is, however, essentially different from all others which have so far been proposed by scientific men. In all the previous instances only a minute fraction of the total energy reaching the planet—as much as it would be possible to concentrate in a reflector—could be utilized by the supposed observer in his instrument. But by the means I have developed he would be enabled to concentrate the larger portion of the entire energy transmitted to the planet in his instrument, and the chances of affecting the latter are thereby increased many millionfold.

Besides machinery for producing vibrations of the required power, we must have delicate means capable of revealing the effects of feeble influences exerted upon the earth. For such purposes, too, I have perfected new methods. By their use we shall likewise be able, among other things, to detect at considerable distance the presence of an iceberg or other object at sea. By their use, also, I have discovered some terrestrial phenomena still unexplained. That we can send a message to a planet is certain, that we can get an answer is probable: man is not the only being in the Infinite gifted with a mind.

TRANSMISSION OF ELECTRICAL ENERGY TO ANY DISTANCE WITHOUT WIRES—NOW PRACTICABLE—THE BEST MEANS OF INCREASING THE FORCE ACCELERATING THE HUMAN MASS.

THE most valuable observation made in the course of these investigations was the extraordinary behavior of the atmosphere toward electric impulses of excessive electromotive force. The experiments showed that the air at the ordinary pressure became distinctly conducting, and this opened up the wonderful prospect of transmitting large amounts of electrical energy for industrial purposes to great distances without wires, a possibility which, up to that time, was thought of only as a scientific dream. Further investigation revealed the important fact that the conductivity imparted to the air by these electrical impulses of many millions of volts increased very rapidly with the degree of rarefaction, so that air strata at very moderate altitudes, which are easily accessible, offer, to all experimental evidence, a perfect conducting path, better than a copper wire, for currents of this character.

Thus the discovery of these new properties of the atmosphere not only opened up the possibility of transmitting, without wires, energy in large amounts, but, what was still more significant, it afforded the certitude that energy could be transmitted in this manner economically. In this new system it matters little—in fact, almost

nothing—whether the transmission is effected at a distance of a few miles or of a few thousand miles.

While I have not, as yet, actually effected a transmission of a considerable amount of energy, such as would be of industrial importance, to a great distance by this new method, I have operated several model plants under exactly the same conditions which will exist in a large plant of this kind, and the practicability of the system is thoroughly demonstrated. The experiments have shown conclusively that, with two terminals maintained at an elevation of not more than thirty thousand to thirty-five thousand feet above sea-level, and with an electrical pressure of fifteen to twenty million volts, the energy of thousands of horse-power can be transmitted over distances which may be hundreds and, if necessary, thousands of miles. I am hopeful, however, that I may be able to reduce very considerably the elevation of the terminals now required, and with this object I am following up an idea which promises such a realization. There is, of course, a popular prejudice against using an electrical pressure of millions of volts, which may cause sparks to fly at distances of hundreds of feet, but, paradoxical as it may seem, the system, as I have described it in a technical publication, offers greater personal safety than most of the ordinary distribution circuits now used in the cities. This is, in a measure, borne out by the fact that, although I have carried on such experiments for a number of years, no injury has been sustained either by me or any of my assistants.

But to enable a practical introduction of the system, a number of essential requirements are still to be fulfilled. It is not enough to develop appliances by means of which such a transmission can be effected. The machinery must be such as to allow the transformation and transmission of electrical energy under highly economical and practical conditions. Furthermore, an inducement must be offered to those who are engaged in the industrial exploitation of natural sources of power, as waterfalls, by guaranteeing greater returns on the capital invested than they can secure by local development of the property.

From that moment when it was observed that, contrary to the established opinion, low and easily accessible strata of the atmosphere are capable of conducting electricity, the transmission of electrical energy without wires has become a rational task of the engineer, and one surpassing all others in importance. Its practical consummation would mean that energy would be available for the uses of man at any point of the globe, not in small amounts such as might be derived from the ambient medium by suitable machinery, but in quantities virtually unlimited, from waterfalls. Export of power would then become the chief source of income for many happily situated countries, as the United States, Canada, Central and South America, Switzerland, and Sweden. Men could settle down everywhere, fertilize and irrigate the soil with little effort, and convert barren deserts into gardens, and thus the entire globe could be transformed and made a fitter abode for mankind. It is highly probable that if there are intelligent beings on Mars they have long ago realized this very idea, which would explain the changes on its surface noted by astronomers. The atmosphere on that planet, being of considerably smaller density than that of the earth, would make the task much more easy.

It is probable that we shall soon have a self-acting heat-engine capable of deriving moderate amounts of energy from the ambient medium. There is also a possibility—though a small one—that we may obtain electrical energy direct from the sun. This might be the case if the Maxwellian theory is true, according to which electrical vibrations of all rates should emanate from the sun. I am still investigating this subject. Sir William Crookes has shown in his beautiful invention known as the "radiometer" that rays may produce by impact a mechanical effect, and this may lead to some important revelation as to the utilization of the sun's rays in novel ways. Other sources of energy may be opened up, and new methods of deriving energy from the sun discovered, but none of these or similar achievements would equal in importance the transmission of power to any distance through the medium. I can conceive of no technical advance which would tend to unite the various elements of humanity more effectively than this one, or of one which would more add to and more economize human energy. It would be the best means of increasing the force accelerating the human mass. The mere moral influence of such a radical departure would be incalculable. On the other hand, if at any point of the globe energy can be obtained in limited quantities from the ambient medium by means of a self-acting heat-engine or otherwise, the conditions will remain the same as before. Human performance will be increased, but men will remain strangers as they were.

I anticipate that many, unprepared for these results, which, through long familiarity, appear to me simple and obvious, will consider them still far from practical application. Such reserve, and even opposition, of some is as useful a quality and as necessary an element in human progress as the quick receptivity and enthusiasm of others. Thus, a mass which resists the force at first, once set in movement, adds to the energy. The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up. His work is like that of the planter—for the future. His duty is to lay the foundation for those who are to come, and point the way. He lives and labors and hopes with the poet who says:

Schaff', das Tagwerk meiner Hände,
Hohes Glück, dass ich's vollende!
Lass, o lass mich nicht ermatten!
Nein, es sind nicht leere Träume:
Jetzt nur Stangen, diese Bäume
Geben einst noch Frucht und Schatten.[1]

[1] Daily work—my hands' employment,
To complete is pure enjoyment!
Let, oh, let me never falter!
No! there is no empty dreaming:
Lo! these trees, but bare poles seeming,
Yet will yield both fruit and shelter!
Goethe's "Hope,"
Translated by William Gibson, Com. U. S. N.

LATITUDE AND LONGITUDE AMONG REFORMERS.

BY THEODORE ROOSEVELT.

ONE of Miss Mary E. Wilkins's delightful heroines remarks, in speaking of certain would-be leaders of social reform in her village: "I don't know that I think they are so much above us as too far to one side. Sometimes it is longitude and sometimes it is latitude that separates people." This is true, and the philosophy it teaches applies quite as much to those who would reform the politics of a large city, or, for that matter, of the whole country, as to those who would reform the society of a hamlet.

There is always danger of being misunderstood when one writes about such a subject as this, because there are on each side unhealthy extremists who like to take half of any statement and twist it into an argument in favor of themselves or against their opponents. No single sentence or two is sufficient to explain a man's full meaning, any more than in a sentence or two it would be possible to treat the question of the necessity for, and the limitations of, proper party loyalty, with the thoroughness and justice shown, for instance, by Mr. Lecky in his recent queerly named volume, "The Map of Life."

All men in whose character there is not an element of hardened baseness must admit the need in our public life of those qualities which we somewhat vaguely group together when we speak of "reform," and all men of sound mind must also admit the need of efficiency. There are, of course, men of such low moral type, or of such ingrained cynicism, that they do not believe in the possibility of making anything better, or do not care to see things better. There are also men who are slightly disordered mentally, or who are cursed with a moral twist which makes them champion reforms less from a desire to do good to others than as a kind of tribute to their own righteousness, for the sake of emphasizing their own superiority. From neither of these classes can we get any real help in the unending struggle for righteousness. There remains the great body of the people, including the entire body of those through whom the salvation of the people must ultimately be worked out. All these men combine or seek to combine in varying degrees the quality of striving after the ideal, that is, the quality which makes men reformers, and the quality of so striving through practical methods—the quality which makes men efficient. Both qualities are absolutely essential. The absence of either makes the presence of the other worthless or worse.

If there is one tendency of the day which more than any other is unhealthy and undesirable, it is the tendency to deify mere "smartness," unaccompanied by a sense of moral accountability. We shall never make our republic what it should be until as a people we thoroughly understand and put in practice the doctrine that success is abhorrent if attained by the sacrifice of the fundamental principles of morality. The successful man, whether in business or in politics, who has risen by conscienceless swindling of his neighbors, by deceit and chicanery, by

The Boston Post
Boston, Mass. Sept 3, 1901

Mr. R. U. Johnson,
The Century Magazine,
New York City

My dear Mr. Johnson: --

I have persuaded Mr. Kinraide to carry over to New York the Electrical Photographs of which you may remember I wrote you some time ago. I am sure you will, at least, be much interested in seeing them.

Mr. Kinraide will call on you probably on Thursday of this week.

Very truly yours,
Anabel Parker
76 Munroe St.
Roxbury, Mass.

Hotel Imperial
Absolutely Fire-Proof
BROADWAY & 32ND STREET
NEW YORK
-ROBERT STAFFORD-

My dear Mr. Johnson,

I am quite ill this morning, it is impossible for me to leave my room to come to you. I will communicate with you as soon as I am able to do so.

The oppressive heat of yesterday was too much for me.

With many regrest[sic] I am,

Sept. 5 – 1901 Sincerely yours,
T. B. Kinraide

Hotel Imperial
Absolutely Fire-Proof
BROADWAY & 32ND STREET
NEW YORK
-ROBERT STAFFORD-

Dear Mr. Johnson,

I am so ill, that I feel it imprudent to remain here any longer. I am returning home tonight on the boat. Will you kindly take care of photographs, putting them in box, face down; until I communicate with you.

Sincerely,
T B Kinraide

Jamaica Plain
Sept 16 1901

Mr R U Johnson

Dear Mr. Johnson,

I think you for your intrest[sic] in my recovery from the ill turn I had in N. Y. I feel able to try it over again – meaning of cours – to be more careful of myself.

I found the same edition of Lord Armstrong's work in our library and have read it carefully.

It makes no reference to the discoveries I have made and in no way conflicts with the article. I will be more than glad to give Lord Armstrong due credit for what he has done in a suitable manner in the article after we have decided upon what can be done with it.

I feel greatly indebted to Mr. Tessla[sic] for bringing my attention to a work that I would have had to apologize for not knowing about it. I am also indebted to you for the pleasure of meeting so estimable a man – Mr. Tessla.

I expect to be in New York about the middle of this week and hope to be able to come to a satisfactory decision both as to the article and photographs.

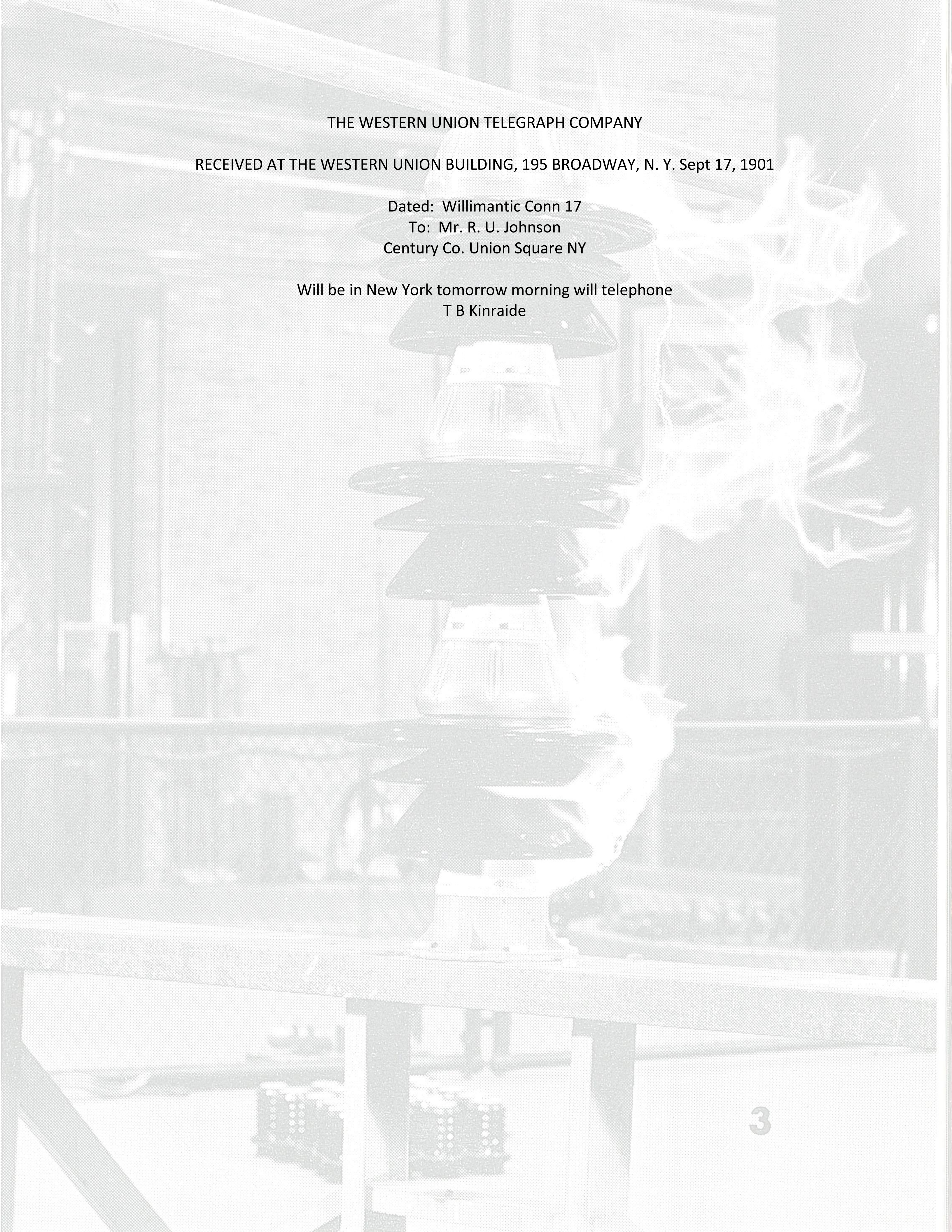
Yours very sincerely,
T. B. Kinraide

THE WESTERN UNION TELEGRAPH COMPANY

RECEIVED AT THE WESTERN UNION BUILDING, 195 BROADWAY, N. Y. Sept 17, 1901

Dated: Willimantic Conn 17
To: Mr. R. U. Johnson
Century Co. Union Square NY

Will be in New York tomorrow morning will telephone
T B Kinraide



Mar 15 1902

Dear Mr Johnson

Your very pleasant letter of the 11 has been forwarded to me here. I have forwarded it to Miss Parker who I am sure will take much pleasure in reading it and will make the changed you suggest. The only reason I have, for not writing the article myself was as you say, that my technical methods of expression could never be used in such a paper. I therefore choose a layman instead.

I assure you I am very sincerely yours,

T B Kinraide

THE BOSTON POST

Boston, Mass. March 21, 1902

Mr. R. U. Johnson
The Century Magazine

My dear Mr. Johnson,

Mr. Kinraide has sent me the manuscript of your article in regard to his experiments. I have made the changes suggested and I hope the copy as as now stands will be available. There is no objection to your cutting out the first two and the last paragraphs, should you wish to do so for space considerations. The paragraph on page 10, beginning "Examine for a moment" could also be eliminated without seriously marring the purpose of the article. Both Mr. Kinraide and myself should honestly be glad if the article could be used in full. It has been prepared with a deal of painstaking and a serious desire to make it at the same time "popular" and scientifically accurate. I feel myself, deeply indebted to Mr. Kinraide for his untiring patience and kindness, and, quite as much for his sake as my own should be glad to have it given good space and make-up.

I should be glad to see proofs of the make-up, if it would be in accord with your custom to permit me to.

By this same mail I am sending to Mr. Kinraide, who is now in Savannah, Ga. the underlining changes. I shall ask him to write or wire you that they meet his approval.

Should your find further changes desirable upon a second reading, I will endeavor to make them. I appreciate that time you take up the matter without being familiar with the experimental work. You are in the best possible position to judge whether or not it is quite clear enough to be understood by the average reader.

Thanking you for your kindly courtesy, I am, truly yours,

Anabel Parker
The Boston Post
Boston

THE WESTERN UNION TELEGRAPH COMPANY

RECEIVED AT THE WESTERN UNION BUILDING, 195 BROADWAY, N. Y. Mar 25, 1902

Dated: Charleston
To: Mr. R. U. Johnson
Century Pub. Co. New York

Changes in article are ok will be home Monday T B Kinraide

THE BOSTON POST

Boston, Mass. March 25, 1902

Mr. R. U. Johnson
The Century Magazine

My dear Mr. Johnson,

I am unable to tell you whether Mr. Kinraide in speaking to me of photographs of sound waves referred to the work of Prof. S.--------------(?) whom you mention or to that of some other investigator. He mentioned a name, but I am unable now to recall it.

I have written him asking to communicate with you in regard to the matter. His absence in the south renders this delay unavoidable.

Sincerely yours,

Anabel Parker

THE BOSTON POST

Boston, Mass. April 10, 1902

Mr. R. U. Johnson
The Century Magazine

My dear Mr. Johnson,

I have to Thank you for the proofs of the Kinraide article, which I herewith return, corrected.

Mr. Kinraide has just been in. He is pleased with the article as it stands and has no changes to request. If quite agreeable, to be honest he would be glad to see proofs of the halftone cuts when they are ready.

Sincerely yours,
Anabel Parker

Anabel Parker

April 17,1902.

Mr. T.B.Kinraide,

Jamaica Plain, Mass.

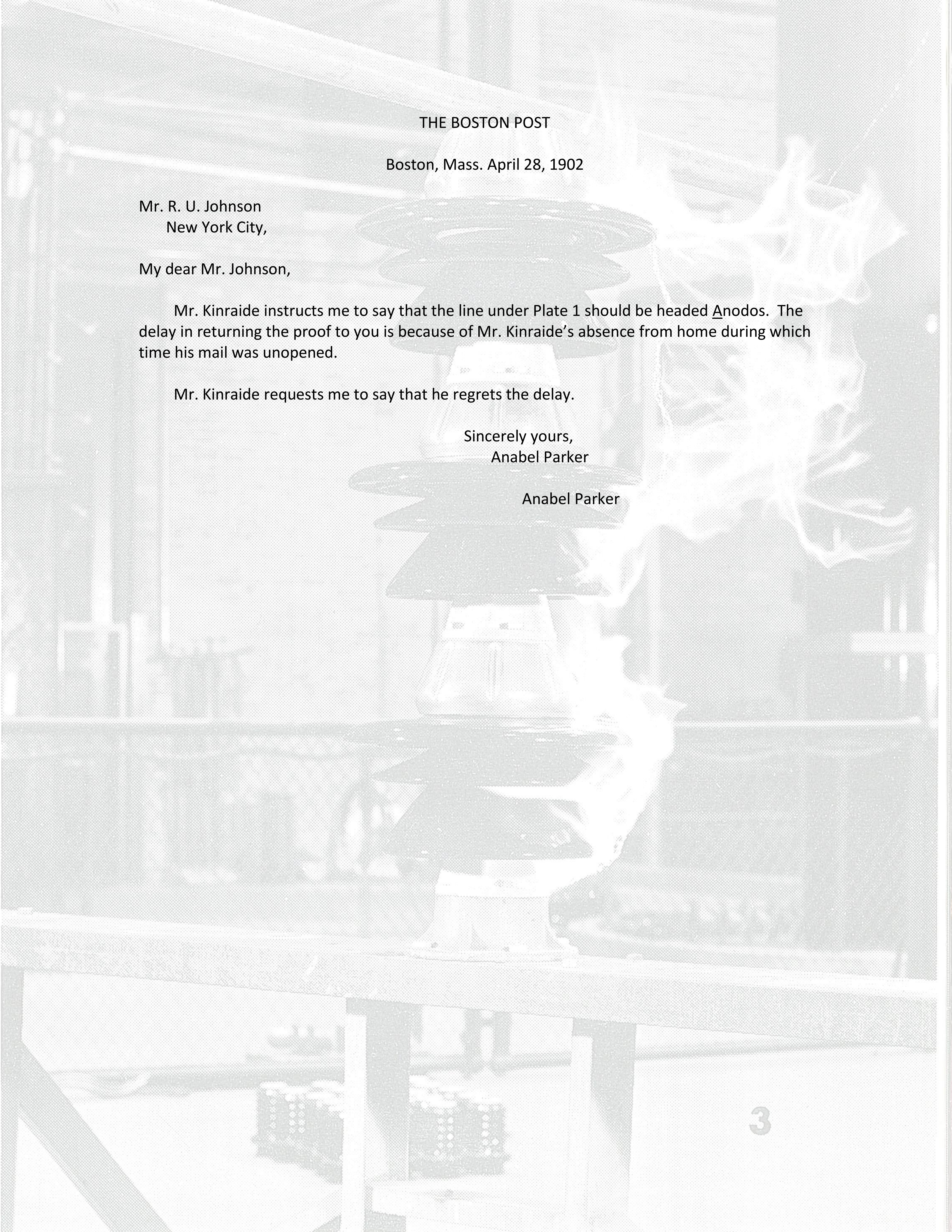
My dear Mr.Kinraide:

I regret that I was called off the other day when you were here and did not have a chance to see you before you left. If you will tell me about what you need in the way of a Crookes'tube I will look over some which I have, and see if there is anything which would suit your purposes. The double focus tubes which are ordinarily made will stand potentials up to four, or five inches or more. They are made for the standard high frequency sets which we have been furnishing for sometime past and you probably know what they are.

I wish again to thank you for the favor of the copies of the enlargements of the spark photographs.

Very truly yours,

Del E.T.



THE BOSTON POST

Boston, Mass. April 28, 1902

Mr. R. U. Johnson
New York City,

My dear Mr. Johnson,

Mr. Kinraide instructs me to say that the line under Plate 1 should be headed Anodos. The delay in returning the proof to you is because of Mr. Kinraide's absence from home during which time his mail was unopened.

Mr. Kinraide requests me to say that he regrets the delay.

Sincerely yours,
Anabel Parker

Anabel Parker

THE BOSTON POST

Boston, Mass. July 14, 1902

Mr. R. U. Johnson
The Century Magazine,

My dear Mr. Johnson,

I am uncertain as to whether or not the matter of payment for my article published in the July number of the Century Magazine was referred to when Mr. Kinraide saw you in New York.

It was understood, however, between Mr. Kinraide and myself that payment for all the matter submitted would be made to me. I write this to forestall any question that might arise regarding this, though perhaps it is unnecessary since you doubtless remember that it was I who submitted the article.

Thanking your kindly courtesy throughout the correspondence, I am,

Very truly yours,
Anabel Parker

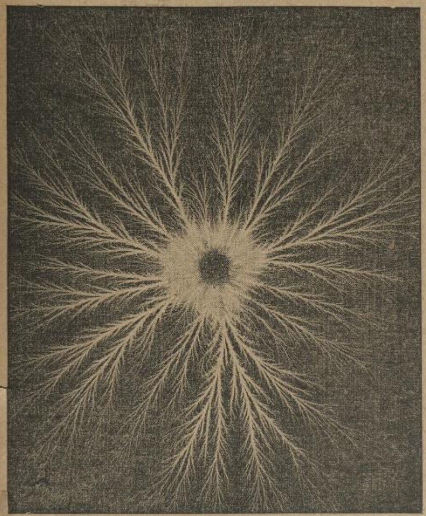
Anabel Parker

World=Astounding Electrical Discoveries Made by Thomas B. Kinraide of Jamaica Plain.

Remarkable Discoveries in X-Rays and Wireless Telegraphy.

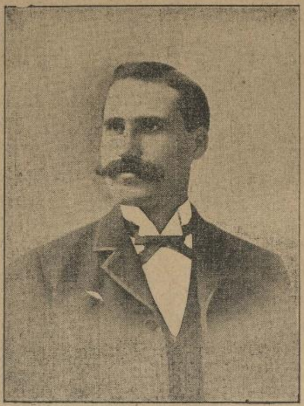
Every Day of His Work Endangers His Life.

Results Attained Will Attract the Attention of Scientists the World Over.



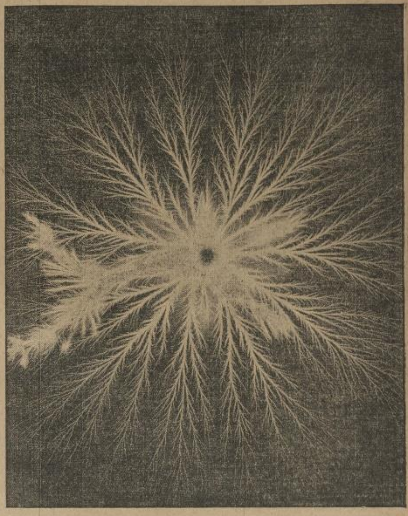
(Copyrighted, 1900, by Thomas B. Kinraide.)

PLATE I.—Negative electricity in its pure form, uninfluenced. It unvaryingly assumes this fern-like structure when discharged into the air. Here the discharge was made to photograph itself upon a sensitive plate.



(Photo by Hastings.)

THOMAS BURTON KINRAIDE.



(Copyrighted, 1900, by Thomas B. Kinraide.)

PLATE II.—The fern-like rays are negative. The feathery, cloudy rays show the unvarying appearance assumed by the positive discharge. This is what Mr. Kinraide calls an electrograph. No camera was used.

There is a man in Jamaica Plain who is in danger of becoming one of the most famous scientists in the world. His neighbors don't know it; the great public hasn't the least suspicion of it. Only a few brother scientists have found him out. Some of the marvellous results of his years of patient experimenting are told the public for the first time in today's Post.

Science, unlike most things else, makes famous in a single day such of her devotees as she deigns to grant a place in the roll of her chosen ones. Long years of patient effort, of working in the dark, of seeking after elusive knowledge, may be futile. Many a man knows that to his sorrow, but they may end in a sudden, dazzling burst of radiance that shall leave a halo round a man's head for the rest of his natural life and as long as human knowledge shall be sought after.

The conclusive grasp of some law in nature that no one before has ever been able to fathom raises a man in a day, as soon as it becomes known, from a humble, ordinary citizen to a position of admittedly absolute power in his particular field of investigation. Edison, Harvey, Faraday, Herschel, Marconi, became famous in a day. The world took no note during their years of patient research. It recked not of sleepless nights, of repeated failures, of heroic perseverance. But when of a morning it woke and heard the news of marvellous results obtained, then the world bowed its head in admiration of the man whose name the day before it had never heard.

To the famous trio of names so notably associated with the development of electrical appliances, Edison, Tesla, Marconi, it seems that a fourth should be added, and this one, happily, that of a Boston man, Thomas B. Kinraide of Jamaica Plain. Mr. Kinraide himself is not seeking the honor. On the contrary, he shrinks in an exceptional degree from public notoriety; but if the predictions of those who ought to know come true, Mr. Kinraide's achievements cannot fail to make him famous the world over.

Mr. Kinraide is a young man, but he has succeeded in doing several things that nobody else has ever done. For one thing, he has succeeded in photographing positive and negative electricity, and has discovered that each has its individual and unvarying form. He has invented a new and powerful form of transmitter to be used in wireless telegraphy, from which he has obtained unprecedented results. He has invented a new form of induction coil and has shown its practical value by its use in his apparatus for X-ray photography, which is the most valuable ever set up. Besides all this, he has conducted experiments along other scientific lines, and has made a set of instruments that will measure over 100,000 sound vibrations per second.

It seems incredible that a man who has already accomplished so much should be so little known. But the reason for it lies in several causes. One of these is that Mr. Kinraide is an exceedingly modest and equally quiet man; another is that he has always had ample means at his command, so that he has not been obliged to work from a commercial standpoint, while still a third reason is that his experiments have always been carried on in his own house and comparatively few people have known anything about them.

HOW HE HAS MADE ELECTRICITY TAKE ITS OWN PICTURE.

Mr. Kinraide is not the first man who has succeeded in photographing electricity, but he is the first man who has been able to secure separate pictures of the positive and the negative, and thus to determine the shape of each. His experiments along this line—in making electricity photograph itself—electrographing, he calls it, began about four years ago. The results are not only of the greatest scientific value—they are marvellously beautiful as well.

In this work no camera is used. The electric fluid is made to print its own picture on ordinary sensitive plates. And the pictures it prints are wonders of graceful designing. Negative electricity has invariably the exquisite fern-shaped appearance shown in the half-tone reproduction on this page. Mr. Kinraide describes this as filisiform, that being the Latin word meaning fern-shaped. Positive electricity has a well-defined feathery appearance, which is more readily noticed when the pictures are enlarged.

Strictly speaking, the positive is formless as compared with the complicated form of the negative. Its appearance is that of a cloud, plume-like, very similar to the cat tails of the long-leaved meadow flag. This plume, varying from six to ten inches in length, is supported upon a delicate stem from one to three inches long, the plume a pale violet color, the stem the vivid white of the electric spark.

Thus far Mr. Kinraide has failed to persuade this form to appear upon the sensitive plate. It is in no way affected by the plate's presence, completely ignoring it, except to fog the plate where it passes through it. Only by using the negative electricity in controlling it has he succeeded in photographing modifications of this form.

The half-tone reproduction on this page marked "negative electricity in its pure form, uninfluenced," is one of a valuable series of pictures of the negative current. The first plate in the series shows just one frond or fern leaf starting from the centre. The second shows two or three, and the succeeding plates show each a greater number of fronds until the perfect number seen in the plate here is found.

In the printing of each plate the current is broken but once, but the delicacy of the apparatus permits the amount of the discharge to be regulated. This graceful and beautiful fern shape is, Mr. Kinraide believes, the natural form of negative electricity whenever it is discharged into the air and is uninfluenced. To the ordinary man it is a surprise to be told that electricity has any defined shape. But that it has, Mr. Kinraide's pictures unquestionably prove.



(Copyrighted, 1900, by Thomas B. Kinraide.)

X-ray picture taken in less than one second's exposure, showing the definition secured both with and without screen. This gives the clearest definition in the shortest time so far secured.

In a recent lecture before a body of scientists at the Massachusetts Institute of Technology Mr. Kinraide, in referring to this, said:

"I trust that I will not be too severely condemned for having become infatuated with the beauty that this work has presented to me. No words that I can use can express the grace and splendor that these forms reveal. To me it has been a revelation of a world beautiful, hidden hitherto and unknown.

"These beautiful shapes are the true symbols of electricity, and in time to come I sincerely trust that when we see electricity symbolized it will either be a figure holding these fronds or the fronds themselves.

"I cannot but feel that the artist will welcome these photographs as studies that cannot be found elsewhere.

"We have all experienced a feeling of awe when dealing with this peculiar force, but have not hitherto seen it in such a way as to be moved to admiration. Now that the opportunity is presented to you to see this force embodied in its true form, incarnated, as it were, and revealed to your eyes, you will not only know it better, but will give to it the sincere appreciation that most certainly is its due."

In securing these electrographs the electrical current is made to discharge from a sphere. Sometimes it happens that the sphere attracts to itself electricity from the air. Then there are inward discharges. This creates the most interesting phenomena of all. The Post plate numbered 3, which is a section of a large plate, shows the formation of the inward discharge. It is seen to be both positive and negative. The light, triangular spot has at the base of the triangle the outshooting of the characteristic fern-like negative electricity. From its direction it can be seen that this is shooting in towards the sphere. At the apex of the triangle is the plumous positive. Somehow the two merge or are united in the triangular space.

Wherever these triangles are found there is the same arrangement, the negative emerging from the base, the positive from the apex.

This particular form of electrical phenomena has never before been seen—that is, the juncture of the positive and negative electricities base to base. This juncture has always been hidden in the apparatus in which the electrical charge was developed, only the outer, fern-like negative and plumous positive having been visible.

This alone contains a world of revelation, which Mr. Kinraide believes is the key which will unlock many of the mysteries hitherto associated with electricity.

It will have particular value in the ultimate conclusion at which Mr. Kinraide hopes to be able to arrive as a result of his electrographing. As yet he has not finished his experimenting in this line, and he is not willing to commit himself to any statement as to what the plates already secured show in regard to the nature of electricity. He does admit, however, that the theory which is forming in his mind, and which these pictures are, one after another, confirming him in, is one that has never been put forward. It is quite different from the theories so far accepted by scientific men in regard to the nature of this wonderful force.

It is not desired in saying this to claim that Mr. Kinraide had a preconceived theory and that he is proving it. It is more correct to say that a theory has been forming in his mind during the years he has been carrying on this line of investigation, and that the various phenomena as they develop all tend to make this theory grow stronger. It has now settled almost into a conviction, but Mr. Kinraide is unwilling yet to formulate it for public utterance.

The theory of the nature of electricity, as now accepted by the most reputable scientists, is that it is either a single fluid or a dual one. The supporters of the former view claim that so-called negative electricity is but the withdrawal or absence of the positive or real electricity. Mr. Kinraide is convinced that his photographing experiments are to settle this much debated question once and for all. He believes that they will even do more than this, that they will give scientists such a clear knowledge of the nature and character of this mighty force that study of electrical development on all lines will be rendered vastly more intelligible. In this way his work, which might seem at first glance the pastime or hobby of a man of leisure, will have a distinctly practical and commercial character, and prove of inestimable value to the public at large.

FAILURES BEFORE SUCCESS.

It could not be expected that these remarkable electrographs would be secured until after repeated attempts. "These beautiful and perfect plates do not tell the story of my many failures," said Mr. Kinraide, "but I have a stack of spoiled negatives big enough to make a greenhouse. Disappointing failures in securing photographs were not, however, my only ones. I had first to construct my apparatus. After I had discovered the secret of the flat-disc coil I was for weeks at the mercy of the condenser. When I had made that satisfactory I found that the ordinary oil insulation used in high voltage apparatus would not stand the enormous strain. Then I had to work for a long time before I hit upon just this combination of rosin and beeswax that I now use. Then I had to learn the process of developing my plates, as I could not wait to have them sent out to a photographer."

This electrographing apparatus is entirely unique. There is not another like it in the world. It controls a higher voltage for the quantity than any other instrument so far made, this being rendered possible by the new flat disc coil which is Mr. Kinraide's most valuable invention. This consists of No. 34 wire wound concentrically in about 1500 turns and making a disc about twelve inches in diameter. This form of coil will, Mr. Kinraide is confident, supplant the Rumkoff coil in all kinds of electrical appliances used in high voltage work. It will easily withstand a pressure under which the Rumkoff coil splinters to atoms.

The beautifully polished brass sphere from which the current discharges surmounts the apparatus. Upon it the sensitive plate is carefully balanced. When the current is broken the sphere becomes a ball of intensified light. The negative electricity shoots out its graceful, quivering fronds in pale, delicate violet, while the heavier, plumous positive glows with a more brilliant intensity, still violet in tinge. Sometimes these gorgeous displays shoot out into the air to a length of two or three feet. Sometimes they are much shorter. The length depends somewhat upon the size of the sphere used.

Mr. Kinraide has used spheres from one to eight inches in diameter. He has secured the best results from the five and six-inch spheres. With the large ones he uses the largest size plates, 18x22 inches. A record is kept of the exact conditions under which every plate is secured. This record is quite as valuable as the plates, and furnishes a key, as it were, to the various phenomena photographed on them. It gives Mr. Kinraide the materials for an exhaustive treatise. And this he will probably issue at no very distant day. In the meantime, he makes no secret of his work, and in the lecture above referred to he explained quite fully the construction and working of his apparatus.

HIS X-RAY APPARATUS.

Mr. Kinraide has applied the principle of the flat-disc coil to an X-ray appliance with remarkably satisfactory results. Several of his X-ray instruments are in use in this city, one in the Massachusetts General Hospital and one in the Children's Hospital. In both these institutions the operators and physicians speak most enthusiastically of the results obtained. Several prominent physicians of the city are also using them in their private practice. They are valuable not only in radiographing instruments, but, on account of their extreme voltage control, as ozone generators.

The electricity by which these machines are operated is the direct or alternating current of the commercial electricity of the city. A machine for the alternating current has been completed this week in Mr. Kinraide's laboratory for the Troy (N. Y.) Hospital. Mr. Kinraide will personally set it up there and start it in operation.

The X-ray picture of Mr. Kinraide's hand in the plate numbered 4 was taken by one of these instruments. The exposure lasted less than one second. The definition with and without a screen is shown. No such perfect definition has ever before been secured in the same length of time. The plate was an ordinary standard plate and no especial pains was taken in developing it. If an especially prepared X-ray plate had been used it is probable that a much clearer definition would have been secured.

A NEW APPLIANCE FOR WIRELESS TELEGRAPHY.

Probably the most extensive commercial benefits resulting from Mr. Kinraide's experimenting will be in the line of wireless telegraphy. His new coil is destined to revolutionize the apparatus now used for making experiments in this department of electrical science. He has already demonstrated this to his entire satisfaction, and as soon as he is able to discontinue his electrographing work he intends to devote himself exhaustively to perfecting his wireless telegraphy devices. He expects to begin work along this line during the coming summer.

Already he has transmitted signals over short distances with surprising results. His experiments so far have been with the telegraphing device used with wires in lecture halls. With this appliance, yet without even a perpendicular or a ground wire, he has sent signals with perfect ease from the cellar of his house to the cupola, four floors above. This, perhaps, seems simple, but when it is remembered that the house is filled with a network of charged wires in voltages from 20 to 550, with dynamos in constant motion and with storage batteries innumerable, it can be seen that for an electrical impulse to be sent through the various floors and to escape the powerful attractions surrounding it and be recorded by the receiving apparatus is full of significance. As yet, Mr. Kinraide has not used code signals, but he proposes to do so in his forthcoming experiments.

He has had equal success in transmitting electrical impulses from his laboratory to a house at perhaps a quarter of a mile distant. Here, again, neither perpendicular nor ground wire was used, and yet every impulse sent was recorded. This is greater success than that obtained under the recent trials at Blue Hill Observatory, which were carried on under the auspices of the Smithsonian Institution.

All these three instruments made by Mr. Kinraide, the electrographing machine, the X-ray apparatus and the perfected wireless telegraphy appliance, owe their remarkable efficiency to the arrangement of the secondary induction coil. This simple invention seems destined to revolutionize one department—and that a most important one—of high voltage electricity. Just how great its value will ultimately become no one is yet able to foresee.

A WONDERFUL LABORATORY.

The inventor of these wonderfully delicate and sensitive machines is not yet 36 years of age. He is not a large man, yet built with the figure of an athlete. It would be difficult to find anywhere a quieter person. He has the blackest of hair and eyes. There is a reserve power about him that commands respect, and as soon as he begins to speak one listens involuntarily.

A Post reporter found Mr. Kinraide in his laboratory one day this week. Mr. Kinraide could not be induced to talk about himself, although with cordial courtesy he was willing to talk about the great science in which he is so much interested. He allowed the reporter to visit his laboratory and to see the wonderful photographs he has made.

This laboratory is one of the most perfectly equipped in the country. Every appliance that could possibly be needed is at hand. It is the workshop of a man of science rather than of an artisan. The utmost neatness and order prevail, and not a speck of dust is to be discovered. Mr. Kinraide has in his employ several skilled mechanics. His master workman is one of the cleverest men in the country in his line of work. There is a constant buzz of turning wheels, as the dynamos are in constant motion. As before noted, these are run by city power. There is one for the 550 commercial volt and one each for the 220, the 110 and the 20-volt current. Besides this direct current Mr. Kinraide makes use of large storage batteries to furnish him with the intermediate voltages, so that he can use a voltage from zero up to an indefinite number.

To look at the outside of this remarkable laboratory one would never suspect its character. "Ravenscroft," which is the name of the house, looks like the residence of a wealthy man. There is no hint that it is the workshop of a great electrician. But as one steps on to the broad piazza and pulls the bell his ear catches at once the buzzing sound within. Then he knows that there is something besides an afternoon tea going on inside. The whole lower floor of the house at the left of the front entrance is given up to the laboratories, the house being specially designed for this purpose. At the right, in front, is Mr. Kinraide's private office, but leading from the small tiled hallway between is a second hall opening into the residential part of the house.

Up from this inner hall leads the broad stairway to the wide parlors above.

Mr. Kinraide's "dark room," where he makes his photographs, is in the cellar. It is the most interesting room possible to imagine. Access to it is by means of a dark stairway leading from the office. This stairway is panelled in beautifully polished oak and softly carpeted. The room itself is fitted in the same fashion. It is very large and high studded. A brilliant fire of coals glows in the grate. No ray of sunlight can penetrate this fantastic room, but at the touch of a button it can be flooded with brilliant light.

This is, perhaps, the fancy of a man of science. It is certainly a most interesting room. Here Mr. Kinraide takes the wonderful electrographs, which are sure to make him famous. Here, too, he has a lantern for throwing on a screen and studying the plates photographed.

Mr. Kinraide, thus fortunately environed, can work with tranquillity along the line of his chosen profession, not caring whether the world pays any attention to him or no. He does not even advertise the X-ray machine which he has made, and which is so valuable. "There is no need of my doing so," he says. "If a person is in search of an apparatus for X-ray work he will make inquiries and not be satisfied until he finds the best there is. Naturally a man's investigations would lead him to Boston, which seems to be a centre for this work."

HIS EXPERIMENTS ENDANGER HIS LIFE.

One would not suspect from the quiet manner in which Mr. Kinraide talks about his electrical experiments that very much of his work is carried on under the most dangerous conditions. But as a matter of fact he has several times barely escaped electrocuting himself. He frequently receives electrical discharges, and his hands show the marks in their seared flesh.

"The nervous strain under which this work is carried on," he said, "is something practically impossible for anyone to realize. After receiving two or three discharges I am unable to work for a considerable time. Then the fascination of the work comes on me again; I simply cannot stop. It is something that takes possession of one and impels him to go on."

Under the constant recognition of the ever imminent danger to which he is subject, a curious and highly interesting muscular contraction has developed itself in Mr. Kinraide's arms. This contraction, wholly involuntary, is controlled undoubtedly by the nerves of the sympathetic system. It has been the means of saving Mr. Kinraide's life on more than one occasion. It is an instinctive movement which leads him to draw away his arms from the instrument he is working with during the two or three seconds before the force of the current, which he recognizes is coming, reaches him. It is a movement which takes place more quickly than it could be controlled by thought.

This would form an interesting study for the psychologist and neurologist. Upon it Mr. Kinraide depends for his safety.

It is, perhaps, unnecessary to say that Mr. Kinraide is both a man of limitless patience and of great mechanical ability. Had he not been the former, he would never have devoted himself so constantly to his work as to secure the results he has secured; had he not been the latter, he could never have constructed the appliances that have enabled him to reach the front rank among electrical investigators.

Some of the most widely known scientists of this city speak in most cordial terms of the remarkable achievements of Mr. Kinraide.

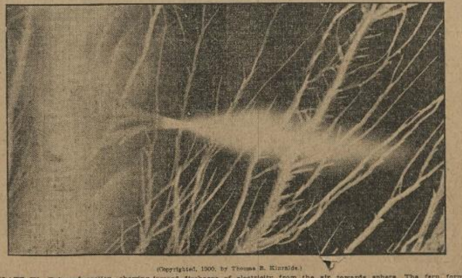
Professor Cross of the Institute of Technology says: "Mr. Kinraide's photographs of the electric spark are certainly the most remarkable ever obtained. He has any amount of inventive genius, and is an exceptionally skilful mechanic. I consider his X-ray screen the best made. Some of his work in acoustics, too, has gone beyond that done by any other investigator. I am told that his X-ray machine is the best that has yet been made. His new form of induction coil is certainly very interesting. About its application to wireless telegraphy I do not know, because I have not investigated it. Mr. Kinraide is an exceedingly modest man. His lecture given here before the Society of Arts could not have been more modestly given."

Dr. C. L. Norton spoke of Mr. Kinraide as "an earnest and capable experimenter and a man of dignified standing among the professional scientists of Boston." He also referred to the various lines of investigation in which Mr. Kinraide had gone deeper than any other experimenter.

OTHER INVESTIGATIONS.

Before beginning this work in electricity Mr. Kinraide had made some very interesting experiments in acoustics. He invented a series of forks which are capable of measuring sound waves from those inaudible to the human ear to those which vibrate over 100,000 times per second. There are about fifty forks in the series. This invention has no practical commercial application, but is of great value in scientific investigation.

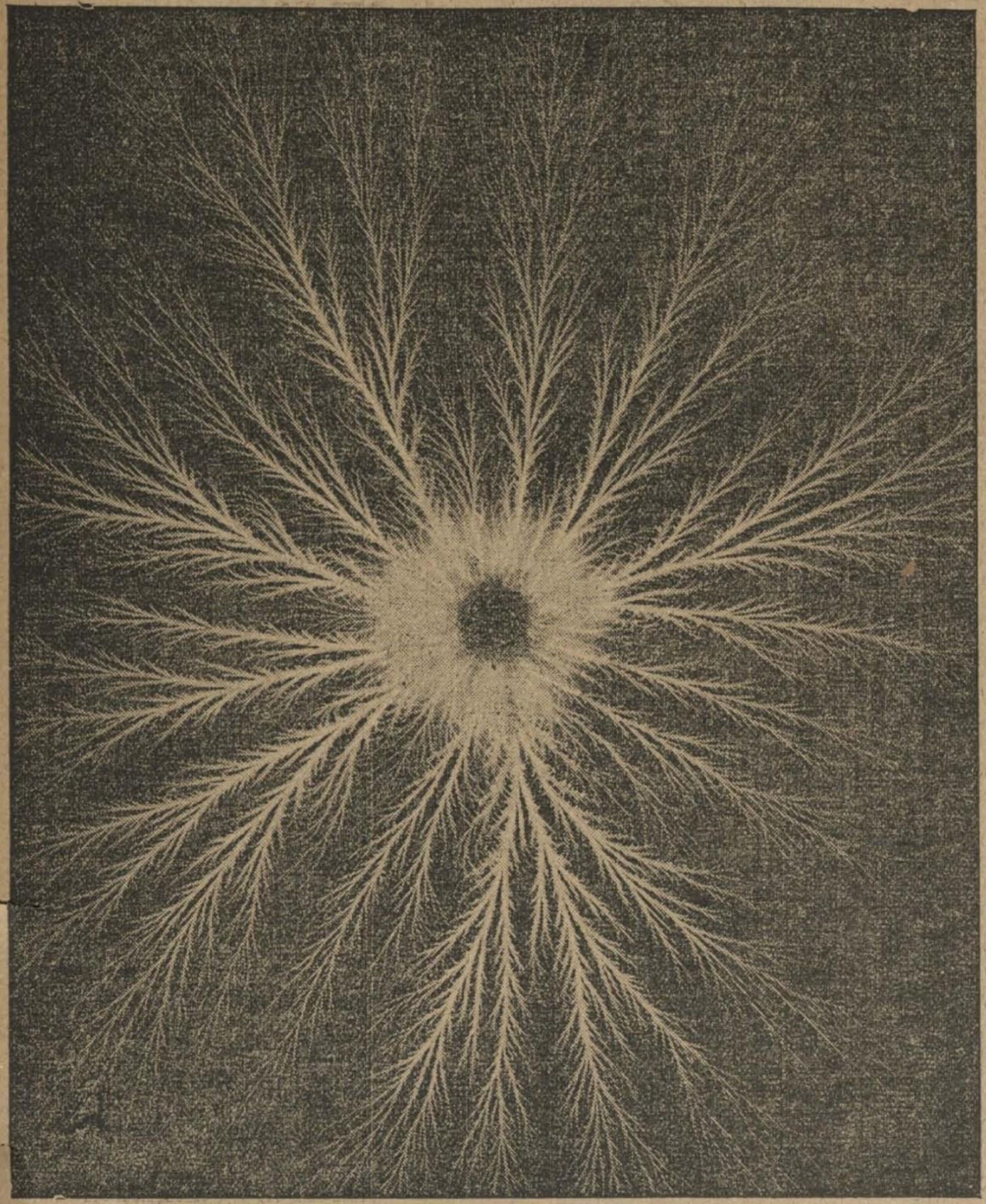
The forthcoming exhibit of Mr. Kinraide's photographs in the Old Corner Bookstore will show to the world for the first time the true forms of electricity. It will also show to the Boston public that one of Boston's citizens, hitherto comparatively unknown, is one of the leading electricians of the age. Mr. Kinraide's limitless patience has already met with its own reward in the marvellous results he has secured, but it has not been recognized as it will be when once the public is apprised of his achievements.



(Copyrighted, 1900, by Thomas B. Kinraide.)

PLATE III.—Enlarged section, showing inward discharge of electricity from the air towards sphere. The fern forms shooting from the base of the white triangle are negative. The filmy, feathery portion at the apex is positive. There is a union of the two in the triangle itself.

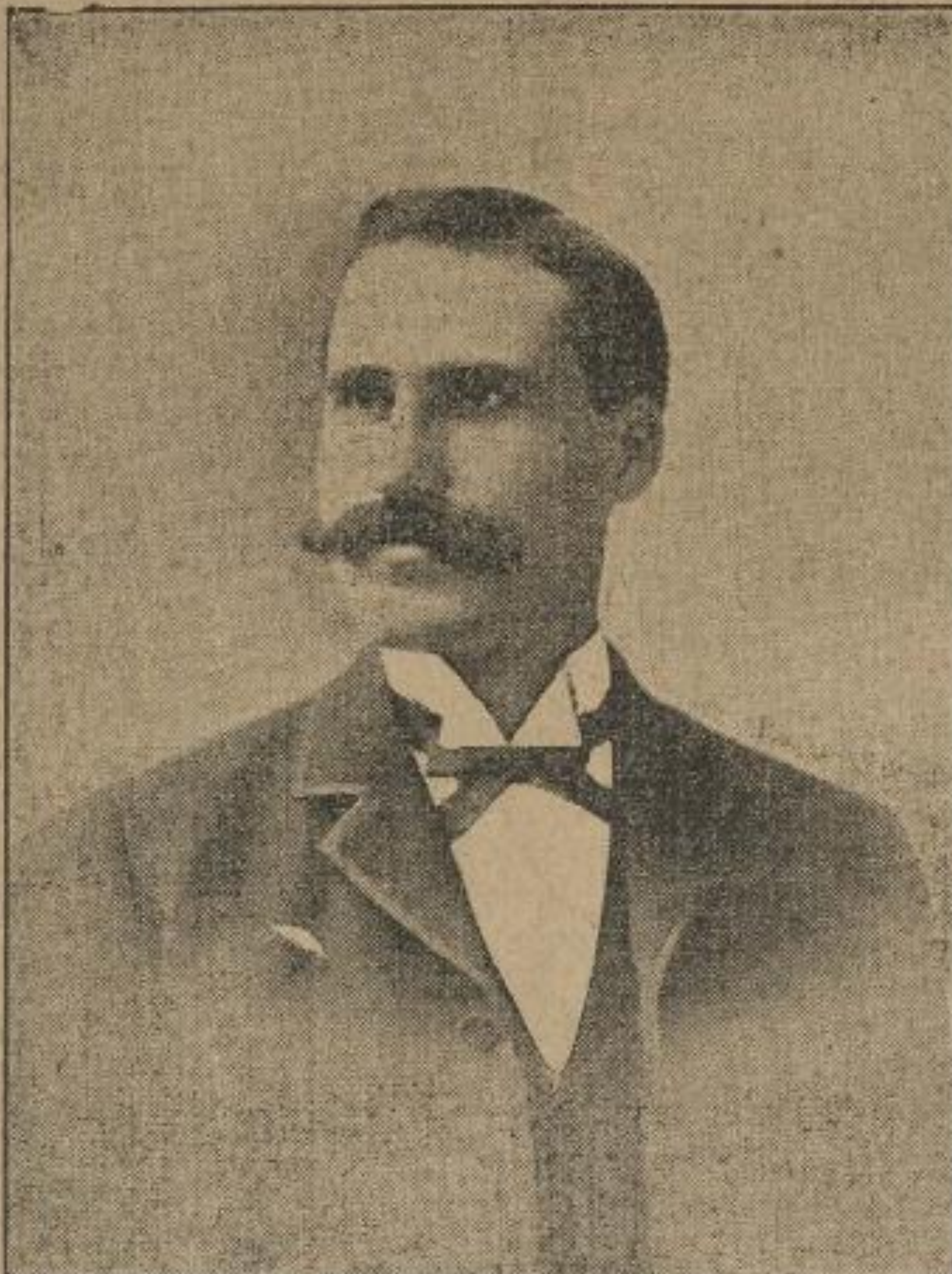
World=Astounding B
Made by Thor



(Copyrighted, 1900, by Thomas B. Kinraide.)

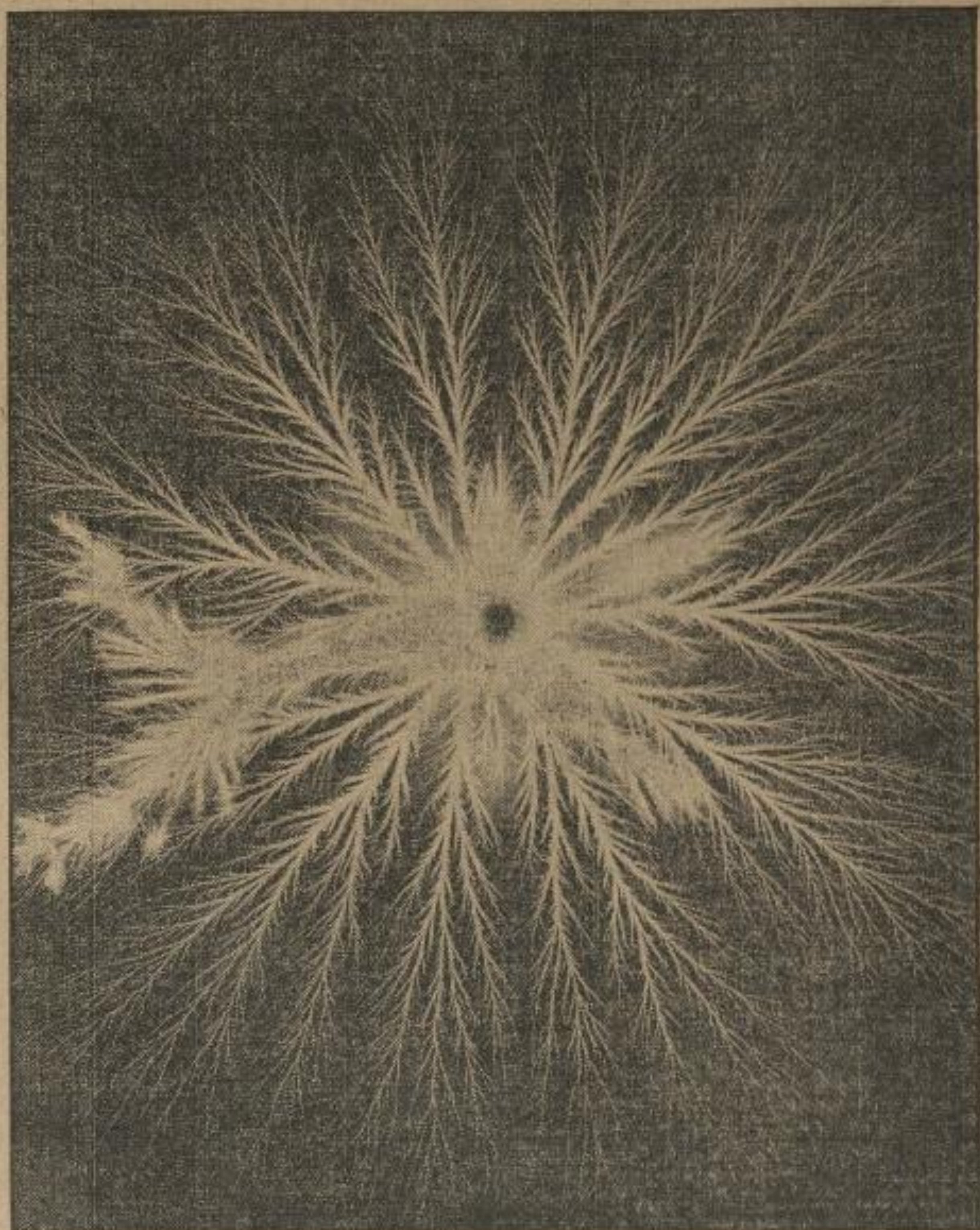
PLATE I.—Negative electricity in its pure form, uninfluenced. It unvaryingly assumes this fern-like structure when discharged into the air. Here the discharge was made to photograph itself upon a sensitive plate.

Results Attained Will Attract the Attention of Scientists the World Over.



(Photo by Hastings.)

THOMAS BURTON KINRAIDE.



(Copyrighted, 1900, by Thomas B. Kinraide.)

PLATE II.—The fern-like rays are negative. The feathery, cloudy rays show the unvarying appearance assumed by the positive discharge. This is what Mr. Kinraide calls an electrograph. No camera was used.

There is a man in Jamaica Plain who is in danger of becoming one of the most famous scientists in the world. His neighbors don't know it; the great public hasn't the least suspicion of it. Only a few brother scientists have found him out. Some of the marvellous results of his years of patient experimenting are told the public for the first time in today's Post.

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The conclusive grasp of some law in nature that no one before has ever been able to fathom raises a man in a day, as soon as it becomes known, from a humble, ordinary citizen to a position of admittedly absolute power in his particular field of investigation. Edison, Harvey, Faraday, Herschel, Marconi, became famous in a day. The world took no note during their years of patient research. It recked not of sleepless nights, of repeated failures, of heroic perseverance. But when of a morning it woke and heard the news of marvellous results obtained, then the world bowed its head in admiration of the man whose name the day before it had never heard.

To the famous trio of names so notably associated with the development of electrical appliances, Edison, Tesla, Marconi, it seems that a fourth should be added, and this one, happily, that of a Boston man, Thomas B. Kinraide of Jamaica Plain. Mr. Kinraide himself is not seeking the honor. On the contrary, he shrinks in an exceptional degree from public notoriety; but if the predictions of those who ought to know come true, Mr. Kinraide's achievements cannot fail to make him famous the world over.

Mr. Kinraide is a young man, but he has succeeded in doing several things that nobody else has ever done. For one thing, he has succeeded in photographing positive and negative electricity, and has discovered that each has its individual and unvarying form. He has invented a new and powerful form of transmitter to be used in wireless telegraphy, from which he has obtained unprecedented results. He has invented a new form of induction coil and has shown its practical value by its use in his apparatus for X-ray photography, which is the most valuable ever set up. Besides all this, he has conducted experiments along other scientific lines, and has made a set of instruments that will measure over 100,000 sound vibrations per second.

It seems incredible that a man who has already accomplished so much should be so little known. But the reason for it lies in several causes. One of these is that Mr. Kinraide is an exceedingly modest and equally quiet man; another is that he has always had ample means at his command, so that he has not been obliged to work from a commercial standpoint, while still a third reason is that his experiments have always been carried on in his own house and comparatively few people have known anything about them.

HOW HE HAS MADE ELECTRICITY TAKE ITS OWN PICTURE.

Mr. Kinraide is not the first man who has succeeded in photographing electricity, but he is the first man who has been able to secure separate pictures of the positive and the negative, and thus to determine the shape of each. His experiments along this line—in making electricity photograph itself—electrographing, he calls it, began about four years ago. The results are not only of the greatest scientific value — they are marvellously beautiful as well.

In this work no camera is used. The electric fluid is made to print its own picture on ordinary sensitive plates. And the pictures it prints are wonders of graceful designing. Negative electricity has invariably the exquisite fern-shaped appearance shown in the half-tone reproduction on this page. Mr. Kinraide describes this as filisiform, that being the Latin word meaning fern-shaped. Positive electricity has a well-defined feathery appearance, which is more readily noticed when the pictures are enlarged.

Strictly speaking, the positive is formless as compared with the complicated form of the negative. Its appearance is that of a cloud, plume-like, very similar to the cat tails of the long-leaved meadow flag. This plume, varying from six to ten inches in length, is supported upon a delicate stem from one to three inches long, the plume a pale violet color, the stem the vivid white of the electric spark.

Thus far Mr. Kinraide has failed to persuade this form to appear upon the sensitive plate. It is in no way affected by the plate's presence, completely ignoring it, except to fog the plate where it passes through it. Only by using the negative electricity in controlling it has he succeeded in photographing modifications of this form.

The half-tone reproduction on this page marked "negative electricity in its pure form, uninfluenced," is one of a valuable series of pictures of the negative current. The first plate in the series shows just one frond or fern leaf starting from the centre. The second shows two or three, and the succeeding plates show each a greater number of fronds until the perfect number seen in the plate here is found.

In the printing of each plate the current is broken but once, but the delicacy of the apparatus permits the amount of the discharge to be regulated. This graceful and beautiful fern shape is, Mr. Kinraide believes, the natural form of negative electricity whenever it is discharged into the air and is uninfluenced. To the ordinary man it is a surprise to be told that electricity has any defined shape. But that it has, Mr. Kinraide's pictures unquestionably prove.

In a recent lecture before a body of scientists at the Massachusetts Institute of Technology Mr. Kinraide, in referring to this, said:

"I trust that I will not be too severely condemned for having become infatuated with the beauty that this work has presented to me. No words that I can use can express the grace and splendor that these forms reveal. To me it has been a revelation of a world beautiful, hidden hitherto and unknown.

"These beautiful shapes are the true symbols of electricity, and in time to come I sincerely trust that when we see electricity symbolized it will either be a figure holding these fronds or the fronds themselves.

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"We have all experienced a feeling of awe when dealing with this peculiar force, but have not hitherto seen it in such a way as to be moved to admiration. Now that the opportunity is presented to you to see this force embodied in its true form, incarnated, as it were, and revealed to your eyes, you will not only know it better, but will give to it the sincere appreciation that most certainly is its due."

In securing these electrographs the electrical current is made to discharge from a sphere. Sometimes it happens that the sphere attracts to itself electricity from the air. Then there are inward discharges. This creates the most interesting phenomena of all. The Post plate numbered 3, which is a section of a large plate, shows the formation of the inward discharge. It is seen to be both positive and negative. The light, triangular spot has at the base of the triangle the outshooting of the characteristic fern-like negative electricity. From its direction it can be seen that this is shooting in towards the sphere. At the apex of the triangle is the plumous positive. Somehow the two merge or are united in the triangular space.

Wherever these triangles are found there is the same arrangement, the negative emerging from the base, the positive from the apex.

This particular form of electrical phenomena has never before been seen—that is, the juncture of the positive and negative electricities base to base. This juncture has always been hidden in the apparatus in which the electrical charge was developed, only the outer, fern-like negative and plumous positive having been visible.

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It is not desired in saying this to claim that Mr. Kinraide had a preconceived theory and that he is proving it. It is more correct to say that a theory has been forming in his mind during the years he has been carrying on this line of investigation, and that the various phenomena as they develop all tend to make this theory grow stronger. It has



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X-ray picture taken in less than one second's exposure, showing the definition secured both with and without screen. This gives the clearest definition in the shortest time so far secured.

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now settled almost into a conviction, but Mr. Kinraide is unwilling yet to formulate it for public utterance.

The theory of the nature of electricity, as now accepted by the most reputable scientists, is that it is either a single fluid or a dual one. The supporters of the former view claim that so-called negative electricity is but the withdrawal or absence of the positive or real electricity. Mr. Kinraide is convinced that his photographing experiments are to settle this much debated question once and for all. He believes that they will even do more than this, that they will give scientists such a clear knowledge of the nature and character of this mighty force that study of electrical development on all lines will be rendered vastly more intelligible. In this way his work, which might seem at first glance the pastime or hobby of a man of leisure, will have a distinctly practical and commercial character, and prove of inestimable value to the public at large.

FAILURES BEFORE SUCCESS.

It could not be expected that these remarkable electrographs would be secured until after repeated attempts. "These beautiful and perfect plates do not tell the story of my many failures," said Mr. Kinraide, "but I have a stack of spoiled negatives big enough to make a greenhouse. Disappointing failures in securing photographs were not, however, my only ones. I had first to construct my apparatus. After I had discovered the secret of the flat-disc coil I was for weeks at the mercy of the condenser. When I had made that satisfactory I found that the ordinary oil insulation used in high voltage apparatus would not stand the enormous strain. Then I had to work for a long time before I hit upon just this combination of rosin and beeswax that I now use. Then I had to learn the process of developing my plates, as I could not wait to have them sent out to a photographer."

This electrographing apparatus is entirely unique. There is not another like it in the world. It controls a higher voltage for the quantity than any other instrument so far made, this being rendered possible by the new flat disc coil which is Mr. Kinraide's most valuable invention. This consists of No. 34 wire wound concentrically in about 1000 turns and making a disc about twelve inches in diameter. This form of coil will, Mr. Kinraide is confident, supplant the Rumkoff coil in all kinds of electrical appliances used in high voltage work. It will easily withstand a pressure under which the Rumkoff coil splinters to atoms.

The beautifully polished brass sphere from which the current discharges surmounts the apparatus. Upon it the sensitive plate is carefully balanced. When the current is broken the sphere becomes a ball of intensified light. The negative electricity shoots out its graceful, quivering fronds in pale, delicate violet, while the heavier, plumous positive glows with a more brilliant intensity, still violet in tinge. Sometimes these gorgeous displays shoot out into the air to a length of two or three feet. Sometimes they are much shorter. The length depends somewhat upon the size of the sphere used.

Mr. Kinraide has used spheres from one to eight inches in diameter. He has secured the best results from the five and six-inch spheres. With the large ones he uses the largest size plates, 18x22 inches. A record is kept of the exact conditions under which every plate is secured. This record is quite as valuable as the plates, and furnishes a key, as it were, to the various phenomena photographed on them. It gives Mr. Kinraide the materials for an exhaustive treatise. And this he will probably issue at no very distant day. In the meantime, he makes no secret of his work, and in the lecture above referred to he explained quite fully the construction and working of his apparatus.

HIS X-RAY APPARATUS.

Mr. Kinraide has applied the principle of the flat-disc coil to an X-ray appliance with remarkably satisfactory results. Several of his X-ray instruments are in use in this city, one in the Massachusetts General Hospital and one in the Children's Hospital. In both these institutions the operators and physicians speak most enthusiastically of the results obtained. Several prominent physicians of the city are also using them in their private practice. They are valuable not only in radiographing instruments, but, on account of their extreme voltage control, as ozone generators.

The electricity by which these machines are operated is the direct or alternating current of the commercial electricity of the city. A machine for the alternating current has been completed this week in Mr. Kinraide's laboratory for the Troy (N. Y.) Hospital. Mr. Kinraide will personally set it up there and start it in operation.

The X-ray picture of Mr. Kinraide's hand in the plate numbered 4 was taken by one of these instruments. The exposure lasted less than one second. The definition with and without a screen is shown. No such perfect definition has ever before been secured in the same length of time. The plate was an ordinary standard plate and no especial pains was taken in developing it. If an especially prepared X-ray plate had been used it is probable that a much clearer definition would have been secured.

A NEW APPLIANCE FOR WIRELESS TELEGRAPHY.

Probably the most extensive commercial benefits resulting from Mr. Kinraide's experimenting will be in the line of wireless telegraphy. His new coil is destined to revolutionize the apparatus now used for making experiments in this department of electrical science. He has already demonstrated this to his entire satisfaction, and as soon as he is able to discontinue his electrographing work he intends to devote himself exhaustively to perfecting his wireless telegraphy devices. He expects to begin work along this line during the coming summer.

Already he has transmitted signals over short distances with surprising results. His experiments so far have been with the telegraphing device used with wires in lecture halls. With this appliance, yet without even a perpendicular or a ground wire, he has sent signals with perfect ease from the cellar of his house to the cupola, four floors above. This, perhaps, seems simple, but when it is remembered that the house is filled with a network of charged wires in voltages from 20 to 550, with dynamos in constant motion and with storage batteries innumerable, it can be seen that for an electrical impulse to be sent through the various floors and to escape the powerful attractions surrounding it and be recorded by the receiving apparatus is full of significance. As yet, Mr. Kinraide has not used code signals, but he proposes to do so in his forthcoming experiments.

He has had equal success in transmitting electrical impulses from his laboratory to a house at perhaps a quarter of a mile distant. Here, again, neither perpendicular nor ground wire was used, and yet every impulse sent was recorded. This is greater success than that obtained under the recent trials at Blue Hill Observatory, which were carried on under the auspices of the Smithsonian Institution.

All these three instruments made by Mr. Kinraide, the electrographing machine, the X-ray apparatus and the perfected wireless telegraphy appliance, owe their remarkable efficiency to the arrangement of the secondary induction coil. This simple invention seems destined to revolutionize one department—and that a most important one—of high voltage electricity. Just how great its value will ultimately become no one is yet able to foresee.

A WONDERFUL LABORATORY.

The inventor of these wonderfully delicate and sensitive machines is not yet 36 years of age. He is not a large man, yet built with the figure of an athlete. It would be difficult to find anywhere a quieter person. He has the blackest of hair and eyes. There is a reserve power about him that commands respect, and as soon as he begins to speak one listens involuntarily.

A Post reporter found Mr. Kinraide in his laboratory one day this week. Mr. Kinraide could not be induced to talk about himself, although with cordial courtesy he was willing to talk about the great science in which he is so much interested. He allowed the reporter to visit his laboratory and to see the wonderful photographs he has made.

This laboratory is one of the most perfectly equipped in the country. Every appliance that could possibly be needed is at hand. It is the workshop of a man of science rather than of an artisan. The utmost neatness and order prevail, and not a speck of dust is to be discovered. Mr. Kinraide has in his employ several skilled mechanics. His master workman is one of the cleverest men in the country in his line of work. There is a constant buzz of turning wheels, as the dynamos are in constant motion. As before noted, these are run by city power. There is one for the 550 commercial volt and one each for the 220, the 110 and the 20-volt current. Besides this direct current Mr. Kinraide makes use of large storage batteries to furnish him with the intermediate voltages, so that he can use a voltage from zero up to an indefinite number.

To look at the outside of this remarkable laboratory one would never suspect its character. "Ravenscroft," which is the name of the house, looks like the residence of a wealthy man. There is no hint that it is the workshop of a great electrician. But as one steps on to the broad piazza and pulls the bell his ear catches at once the buzzing sound within. Then he knows that there is something besides an afternoon tea going on inside. The whole lower floor of the house at the left of the front entrance is given up to the laboratories, the house being specially designed for this purpose. At the right, in front, is Mr. Kinraide's private office, but leading from the small tiled hallway between is a second hall opening into the residential part of the house.

Up from this inner hall leads the broad stairway to the wide parlors above.

Mr. Kinraide's "dark room," where he makes his photographs, is in the cellar. It is the most interesting room possible to imagine. Access to it is by means of a dark stairway leading from the office. This stairway is panelled in beautifully polished oak and softly carpeted. The room itself is fitted in the same fashion. It is very large and high studded. A brilliant fire of coals glows in the grate. No ray of sunlight can penetrate this fantastic room, but at the touch of a button it can be flooded with brilliant light.

This is, perhaps, the fancy of a man of science. It is certainly a most interesting room. Here Mr. Kinraide takes the wonderful electrographs, which are sure to make him famous. Here, too, he has a lantern for throwing on a screen and studying the plates photographed.

Mr. Kinraide, thus fortunately environed, can work with tranquillity along the line of his chosen profession, not caring whether the world pays any attention to him or no. He does not even advertise the X-ray machine which he has made, and which is so valuable. "There is no need of my doing so," he says. "If a person is in search of an apparatus for X-ray work he will make inquiries and not be satisfied until he finds the best there is. Naturally a man's investigations would lead him to Boston, which seems to be a centre for this work."

HIS EXPERIMENTS ENDANGER HIS LIFE.

One would not suspect from the quiet manner in which Mr. Kinraide talks about his electrical experiments that very much of his work is carried on under the most dangerous conditions. But as a matter of fact he has several times barely escaped electrocuting himself. He frequently receives electrical discharges, and his hands show the marks in their seared flesh.

"The nervous strain under which this work is carried on," he said, "is something practically impossible for anyone to realize. After receiving two or three discharges I am unable to work for a considerable time. Then the fascination of the work comes on me again; I simply cannot stop. It is something that takes possession of one and impels him to go on."

Under the constant recognition of the ever imminent danger to which he is subject, a curious and highly interesting muscular contraction has developed itself in Mr. Kinraide's arms. This contraction, wholly involuntary, is controlled undoubtedly by the nerves of the sympathetic system. It has been the means of saving Mr. Kinraide's life on more than one occasion. It is an instinctive movement which leads him to draw away his arms from the instrument he is working with during the two or three seconds before the force of the current, which he recognizes is coming, reaches him. It is a movement which takes place more quickly than it could be controlled by thought.

This would form an interesting study for the psychologist and neurologist. Upon it Mr. Kinraide depends for his safety.

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now settled almost into a conviction, but Mr. Kinraide is unwilling yet to formulate it for public utterance.

The theory of the nature of electricity, as now accepted by the most reputable scientists, is that it is either a single fluid or a dual one. The supporters of the former view claim that so-called negative electricity is but the withdrawal or absence of the positive or real electricity. Mr. Kinraide is convinced that his photographing experiments are to settle this much debated question once and for all. He believes that they will even do more than this, that they will give scientists such a clear knowledge of the nature and character of this mighty force that study of electrical development on all lines will be rendered vastly more intelligible. In this way his work, which might seem at first glance the pastime or hobby of a man of leisure, will have a distinctly practical and commercial character, and prove of inestimable value to the public at large.

FAILURES BEFORE SUCCESS.

It could not be expected that these remarkable electrographs would be secured until after repeated attempts. "These beautiful and perfect plates do not tell the story of my many failures," said Mr. Kinraide, "but I have a stack of spoiled negatives big enough to make a greenhouse. Disappointing failures in securing photographs were not, however, my only ones. I had first to construct my apparatus. After I had discovered the secret of the flat-disc coil I was for weeks at the mercy of the condenser. When I had made that satisfactory I found that the ordinary oil insulation used in high voltage apparatus would not stand the enormous strain. Then I had to work for a long time before I hit upon just this combination of rosin and beeswax that I now use. Then I had to learn the process of developing my plates, as I could not wait to have them sent out to a photographer."

This electrographing apparatus is entirely unique. There is not another like it in the world. It controls a higher voltage for the quantity than any other instrument so far made, this being rendered possible by the new flat disc coil which is Mr. Kinraide's most valuable invention. This consists of No. 34 wire wound concentrically in about 1000 turns and making a disc about twelve inches in diameter. This form of coil will, Mr. Kinraide is confident, supplant the Rumkoff coil in all kinds of electrical appliances used in high voltage work. It will easily withstand a pressure under which the Rumkoff coil splinters to atoms.

The beautifully polished brass sphere from which the current discharges surmounts the apparatus. Upon it the sensitive plate is carefully balanced. When the current is broken the sphere becomes a ball of intensified light. The negative electricity shoots out its graceful, quivering fronds in pale, delicate violet, while the heavier, plumous positive glows with a more brilliant intensity, still violet in tinge. Sometimes these gorgeous displays shoot out into the air to a length of two or three feet. Sometimes they are much shorter. The length depends somewhat upon the size of the sphere used.

Mr. Kinraide has used spheres from one to eight inches in diameter. He has secured the best results from the five and six-inch spheres. With the large ones he uses the largest size plates, 18x22 inches. A record is kept of the exact conditions under which every plate is secured. This record is quite as valuable as the plates, and furnishes a key, as it were, to the

was used.

various phenomena photographed on them. It gives Mr. Kinraide the materials for an exhaustive treatise. And this he will probably issue at no very distant day. In the meantime, he makes no secret of his work, and in the lecture above referred to he explained quite fully the construction and working of his apparatus.

HIS X-RAY APPARATUS.

Mr. Kinraide has applied the principle of the flat-disc coil to an X-ray appliance with remarkably satisfactory results. Several of his X-ray instruments are in use in this city, one in the Massachusetts General Hospital and one in the Children's Hospital. In both these institutions the operators and physicians speak most enthusiastically of the results obtained. Several prominent physicians of the city are also using them in their private practice. They are valuable not only in radiographing instruments, but, on account of their extreme voltage control, as ozone generators.

The electricity by which these machines are operated is the direct or alternating current of the commercial electricity of the city. A machine for the alternating current has been completed this week in Mr. Kinraide's laboratory for the Troy (N. Y.) Hospital. Mr. Kinraide will personally set it up there and start it in operation.

The X-ray picture of Mr. Kinraide's hand in the plate numbered 4 was taken by one of these instruments. The exposure lasted less than one second. The definition with and without a screen is shown. No such perfect definition has ever before been secured in the same length of time. The plate was an ordinary standard plate and no especial pains was taken in developing it. If an especially prepared X-ray plate had been used it is probable that a much clearer definition would have been secured.

A NEW APPLIANCE FOR WIRELESS TELEGRAPHY.

Probably the most extensive commercial benefits resulting from Mr. Kinraide's experimenting will be in the line of wireless telegraphy. His new coil is destined to revolutionize the apparatus now used for making experiments in this department of electrical science. He has already demonstrated this to his entire satisfaction, and as soon as he is able to discontinue his electrographing work he intends to devote himself exhaustively to perfecting his wireless telegraphy devices. He expects to begin work along this line during the coming summer.

Already he has transmitted signals over short distances with surprising results. His experiments so far have been with the telegraphing device used with wires in lecture halls. With this appliance, yet without even a perpendicular or a ground wire, he has sent signals with perfect ease from the cellar of his house to the cupola, four floors above. This, perhaps, seems simple, but when it is remembered that the house is filled with a network of charged wires in voltages from 30 to 500, with dynamos in constant motion and with storage batteries innumerable, it can be seen that for an electrical impulse to be sent through the various floors and to escape the powerful attractions surrounding it and be recorded by the receiving apparatus is full of significance. As yet, Mr. Kinraide has not used code signals, but he proposes to do so in his forthcoming experiments.

He has had equal success in transmitting electrical impulses from his laboratory to a house at perhaps a

quarter of a mile distant. Here, again, neither perpendicular nor ground wire was used, and yet every impulse sent was recorded. This is greater success than that obtained under the recent trials at Blue Hill Observatory, which were carried on under the auspices of the Smithsonian Institution.

All these three instruments made by Mr. Kinraide, the electrographing machine, the X-ray apparatus and the perfected wireless telegraphy appliance, owe their remarkable efficiency to the arrangement of the secondary induction coil. This simple invention seems destined to revolutionize one department—and that a most important one—of high voltage electricity. Just how great its value will ultimately become no one is yet able to foresee.

A WONDERFUL LABORATORY.

The inventor of these wonderfully delicate and sensitive machines is not yet 36 years of age. He is not a large man, yet built with the figure of an athlete. It would be difficult to find anywhere a quieter person. He has the blackest of hair and eyes. There is a reserve power about him that commands respect and as soon as he begins to speak one listens involuntarily.

A Post reporter found Mr. Kinraide in his laboratory one day this week. Mr. Kinraide could not be induced to talk about himself, although with cordial courtesy he was willing to talk about the great science in which he is so much interested. He allowed the reporter to visit his laboratory and to see the wonderful photographs he has made.

This laboratory is one of the most perfectly equipped in the country. Every appliance that could possibly be needed is at hand. It is the workshop of a man of science rather than of an artisan. The utmost neatness and order prevail, and not a speck of dust is to be discovered. Mr. Kinraide has in his employ several skilled mechanics. His master workman is one of the cleverest men in the country in his line of work. There is a constant buzz of turning wheels, as the dynamos are in constant motion. As before noted, these are run by city power. There is one for the 550 commercial volt and one each for the 220, the 110 and the 20-volt current. Besides this direct current Mr. Kinraide makes use of large storage batteries to furnish him with the intermediate voltages, so that he can use a voltage from zero up to an indefinite number.

To look at the outside of this remarkable laboratory one would never suspect its character. "Ravenscroft," which is the name of the house, looks like the residence of a wealthy man. There is no hint that it is the workshop of a great electrician. But as one steps on to the broad piazza and pulls the bell his ear catches at once the buzzing sound within. Then he knows that there is something besides an afternoon tea going on inside. The whole lower floor of the house at the left of the front entrance is given up to the laboratories, the house being specially designed for this purpose. At the right, in front, is Mr. Kinraide's private office, but leading from the small tiled hallway between is a second hall opening into the residential part of the house.

Up from this inner hall leads the broad stairway to the wide parlors above.

Mr. Kinraide's "dark room," where he makes his photographs, is in the cellar. It is the most interesting room possible to imagine. Access to it is by means of a dark stairway leading from the office. This stairway is panelled in beautifully polished oak and softly carpeted. The room itself is fitted in the same fashion. It is very large and high studded. A brilliant fire of coals glows in the grate. No ray of sunlight can penetrate this fantastic room, but at the touch of a button it can be flooded with brilliant light.

This is, perhaps, the fancy of a man of science. It is certainly a most interesting room. Here Mr. Kinraide takes the wonderful electrographs, which are sure to make him famous. Here, too, he has a lantern for throwing on a screen and studying the plates photographed.

Mr. Kinraide, thus fortunately environed, can work with tranquillity along the line of his chosen profession, not caring whether the world pays any attention to him or no. He does not even advertise the X-ray machine which he has made, and which is so valuable. "There is no need of my doing so," he says. "If a person is in search of an apparatus for X-ray work he will make inquiries and not be satisfied until he finds the best there is. Naturally a man's investigations would lead him to Boston, which seems to be a centre for this work."

HIS EXPERIMENTS ENDANGER HIS LIFE.

One would not suspect from the quiet manner in which Mr. Kinraide talks about his electrical experiments that very much of his work is carried on under the most dangerous conditions. But as a matter of fact he has several times barely escaped electrocuting himself. He frequently receives electrical discharges, and his hands show the marks in their seared flesh.

"The nervous strain under which this work is carried on," he said, "is something practically impossible for anyone to realize. After receiving two or three discharges I am unable to work for a considerable time. Then the fascination of the work comes on me again; I simply cannot stop. It is something that takes possession of one and impels him to go on."

Under the constant recognition of the ever imminent danger to which he is subject, a curious and highly interesting muscular contraction has developed itself in Mr. Kinraide's arms. This contraction, wholly involuntary, is controlled undoubtedly by the nerves of the sympathetic system. It has been the means of saving Mr. Kinraide's life on more than one occasion. It is an instinctive movement which leads him to draw away his arms from the instrument he is working with during the two or three seconds before the force of the current, which he recognizes is coming, reaches him. It is a movement which takes place more quickly than it could be controlled by thought.

This would form an interesting study for the psychologist and neurologist. Upon it Mr. Kinraide depends for his safety.

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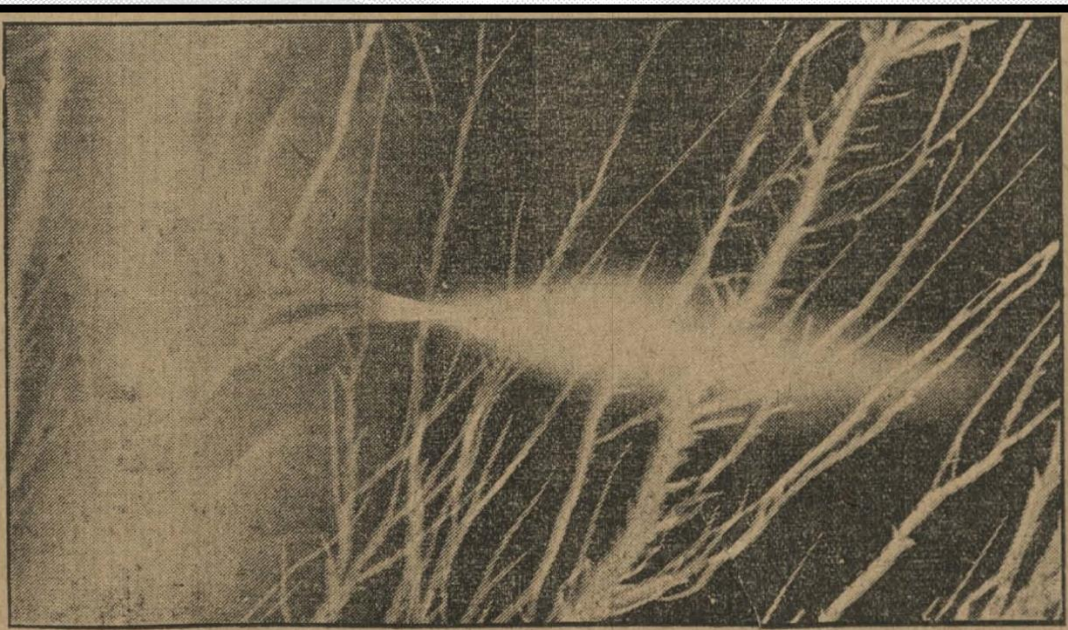
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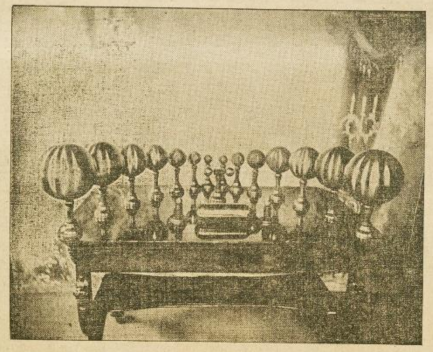
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The exclusive story printed in last Sunday's Post told in a general way some facts shown by these truly marvellous pictures. The theory which has presented itself to Mr. Kinraide's mind as an outcome of his experiments in securing them is here told for the first time. It involves nothing less than a theory of the origin of the universe, suns, moons, stars and planets.

By reference to the plate numbered III. it will be seen that one electrical phenomenon takes the form of a comet. This is a union of the two manifestations of electricity, the positive and the negative, base to base, and, as stated in last Sunday's Post, has never before been seen. Mr. Kinraide has experimented in securing this particular form and has found out under what conditions it can be originated. Whenever he takes a notion now he can go into his dark room and make a shower of these beautiful electrical comets.

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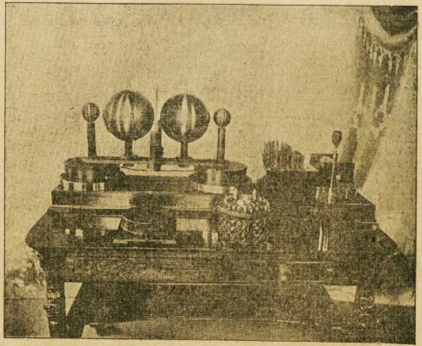
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Of course, Mr. Kinraide reasons, under the same conditions similar results would follow. Then he explains what these results would be. In the first place, he assumes that before the worlds were formed electricity was present everywhere in cosmos. It was the only great physical force then operative. Primarily it then existed in a state of equilibrium.

For some reason or other, the equilibrium was disturbed and then electrical comets went swinging off into space. The negative, going ahead, would be followed in a headlong chase by its brother, positive, trying to catch up with it. For how many billions of leagues this great race may have gone on no one will attempt to say, nor for how many aeons it was kept up. But on and on the chase would sweep through space until something would stop it.

This is how Mr. Kinraide believes it would be stopped. He assumes that in the mad rush the electrical comet would attract to itself cosmic dust in much the same way that any static electrical machine in a laboratory will quickly gather to itself the motes in the air. As time went on this accretion of dust would grow greater and greater. Polarization of the particles of dust in the comet's path would ensue and it would whirl along like a great sweeping machine, gathering into itself whatever came in its way.

In time an enormous mass would be collected. Then the speed of the onrushing force would be retarded and the positive electricity would be able to overtake and unite with the negative.



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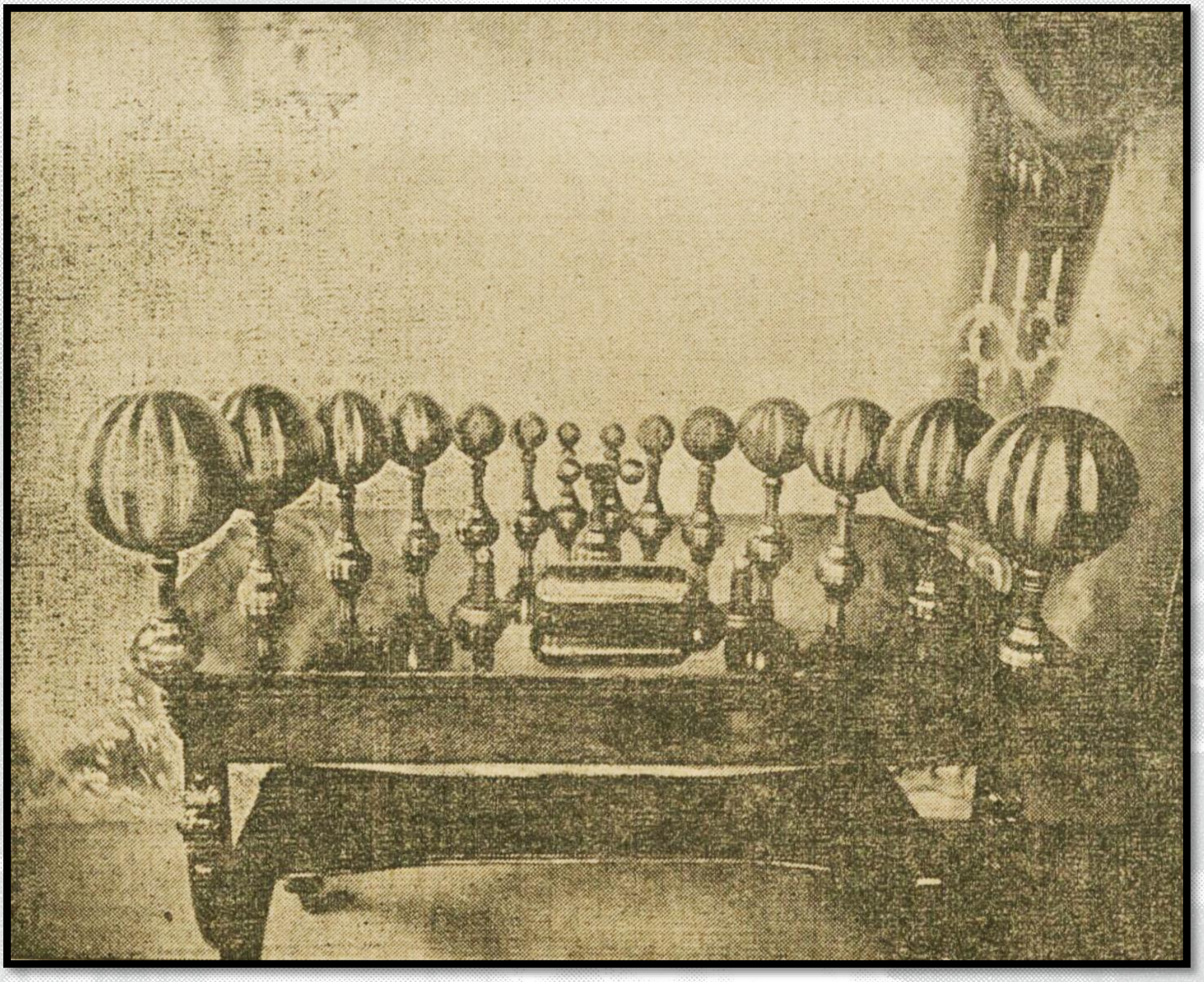
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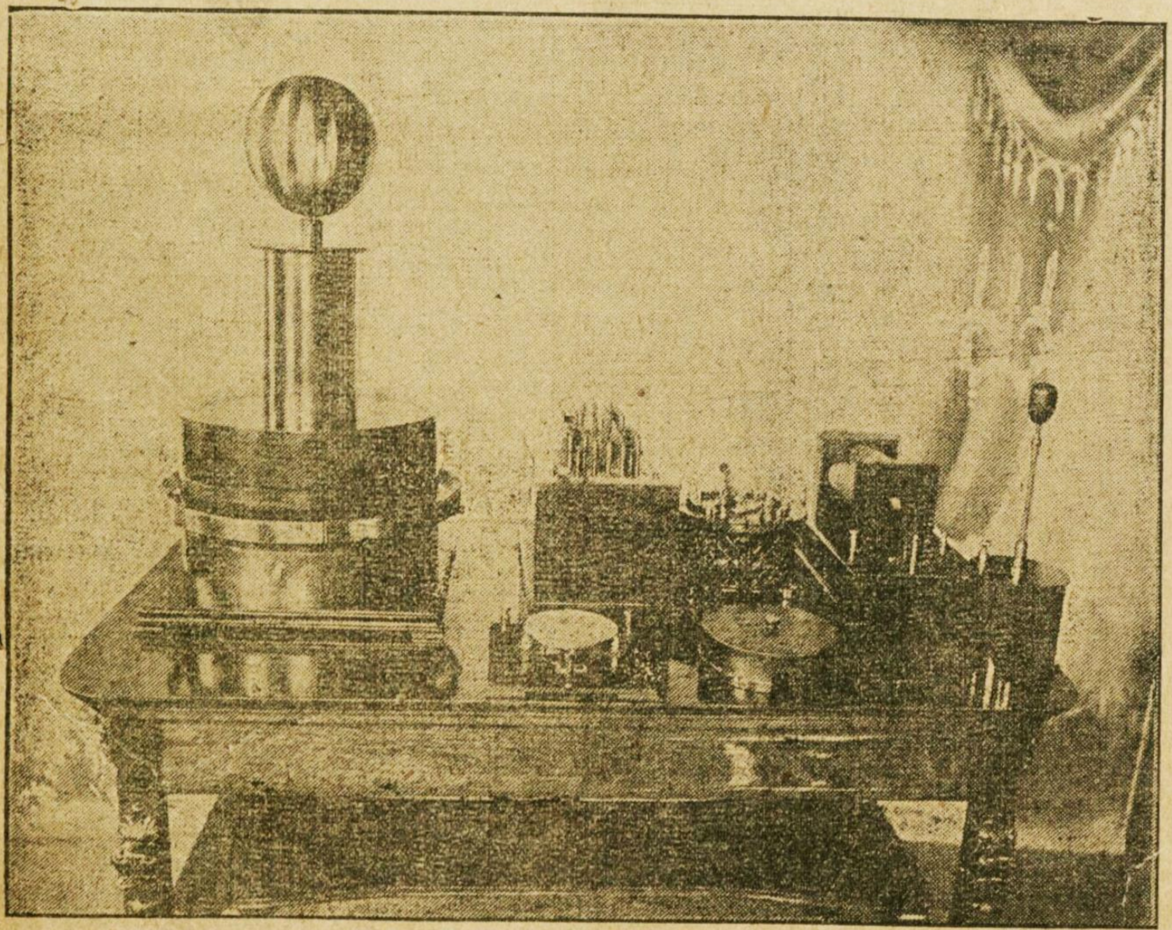
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Replica Kinraide break, built by the author

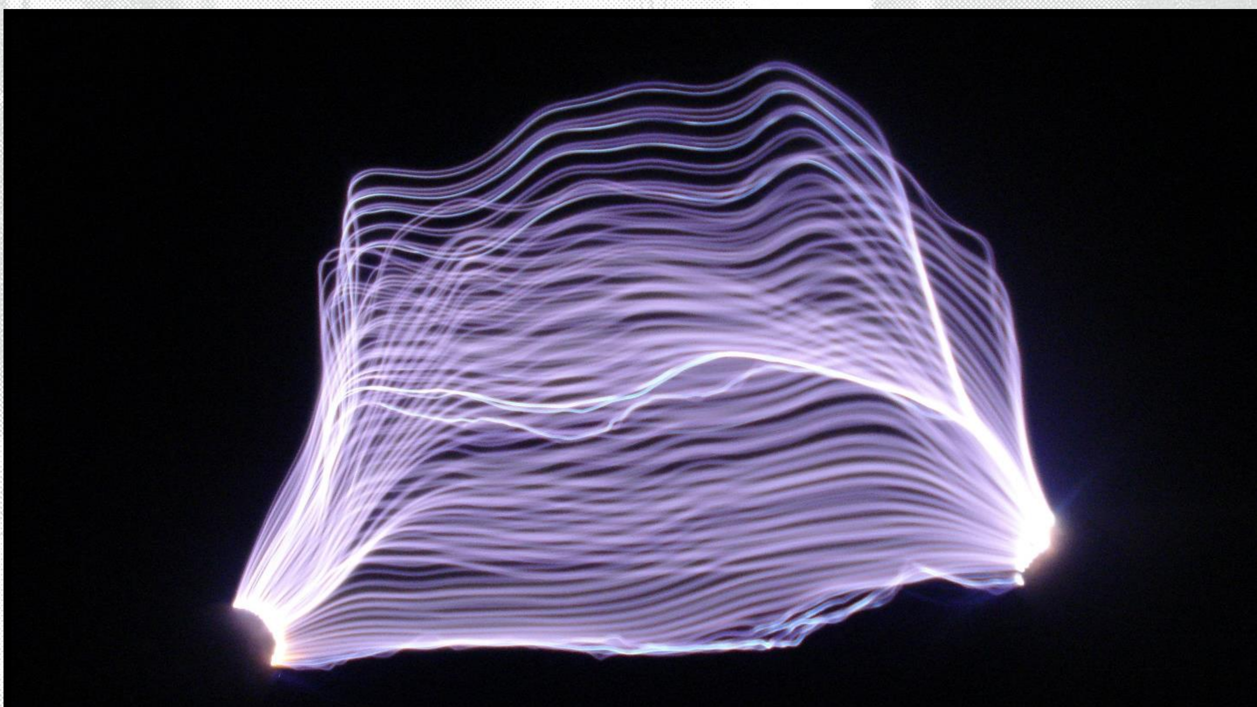


Kinraide's earliest high frequency coils, built on similar principles as Tesla's early disruptive discharge coils. The designs were modifications of the principles of the induction coil, engineered to operate at higher frequencies.



Original Kinraide Coil used to make the electrographs in the Century Magazine article





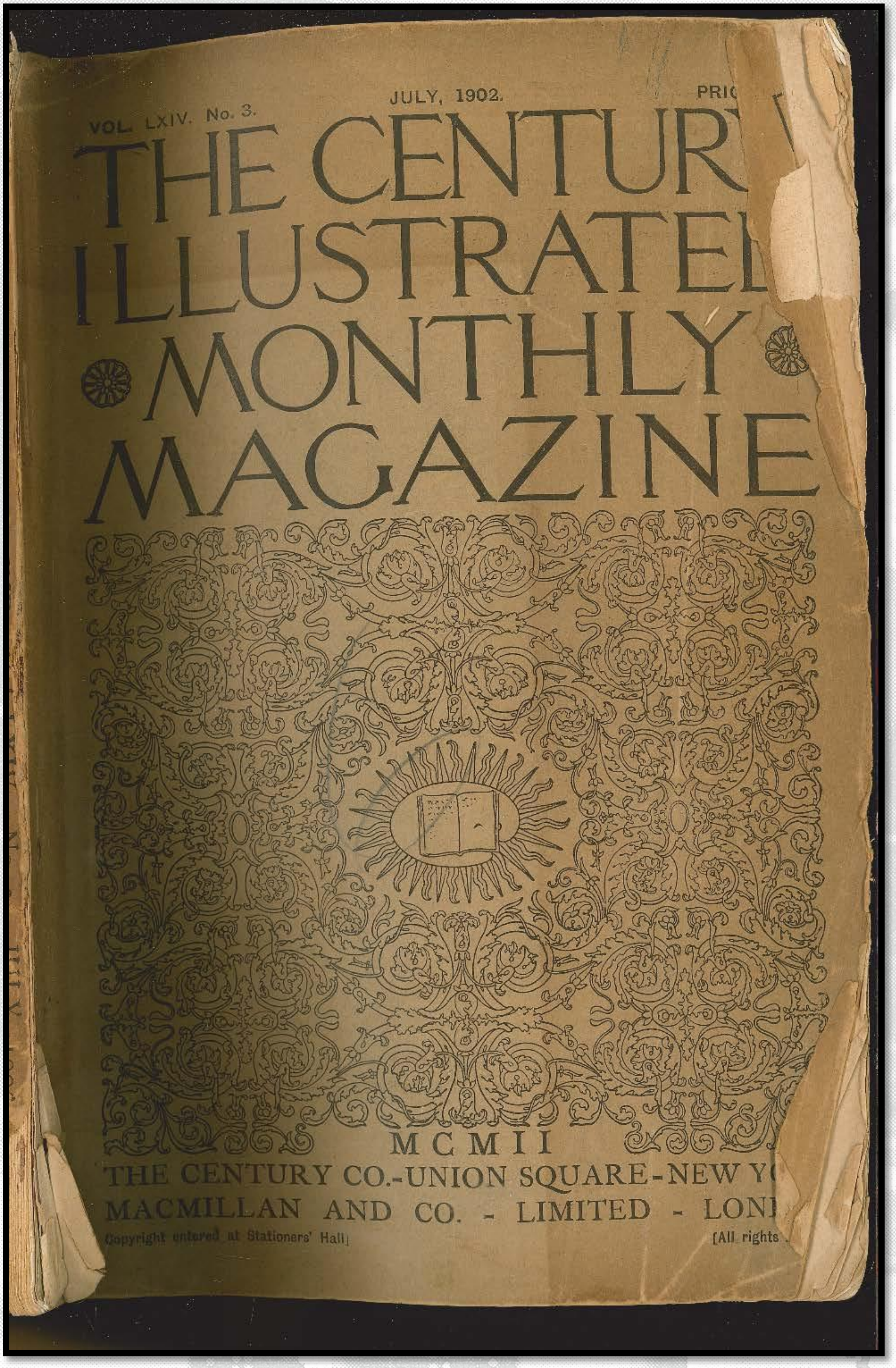




Original Kinraide Coil, restored for the family by the author. The spark gap, two parallel copper disks ¼” thick and 6” diameter, water cooled, formed the basis of the first quenched spark gap.



Thomas Burton Kinraide, Photo from the Kinraide family.



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Two years have gone by, and I am one of the richest men in the city, and have no more money than will keep me alive.

Susan said I was half cracked like Uncle Philip, and broke off her engagement. In my despair I have advertised in the "Journal of Science," and have had absurd schemes sent me by the dozen. At last, as I talked too much about it, the thing became so well known that when I put the horror in a safe, in bank, I was promptly desired to withdraw it. I was in constant fear of burglars, and my landlady gave me notice to leave, because no one would stay in the house with that box. I am now advised to print my story and await advice from the ingenuity of the American mind.

I have moved into the suburbs and hidden the box and changed my name and my occupation. This I did to escape the curiosity of the reporters. I ought to say that when the government officials came to hear of my inheritance, they very reasonably desired to collect the succession tax on my uncle's estate.

I was delighted to assist them. I told the collector my story, and showed him Uncle Philip's letter. Then I offered him the key, and asked for time to get half a mile away. That man said he would think it over and come back later.

This is all I have to say. I have made a will and left my rubies to the Society for the Prevention of Human Vivisection. If any man thinks this account a joke or an invention, let him coldly imagine the situation:

Given an iron box, known to contain wealth, said to contain dynamite, arranged to explode when the key is used to unlock it—what would any sane man do? What would he advise?

CURIOUS ELECTRICAL FORMS.

AS SHOWN IN MR. T. BURTON KINRAIDE'S RECENT PHOTOGRAPHS OF ELECTRICAL DISCHARGES.

BY ANABEL PARKER.

THE remarkable photographs which it is the object of this article to explain constitute a graphic record, a genuine autobiography, of certain phases of one of the most wonderful and subtle of the great forces of nature. They are the result of several years of experimenting by a Boston investigator, T. Burton Kinraide, and are the record of impressions made upon sensitive plates by discharges of electricity. These photographs show the form and character of the so-called positive and negative phases of electric energy, and of a third phase which has never before been revealed. They hint at an apparatus unique in its delicacy of control. Beyond this, they throw fresh light on the very nature and character of this great force.

All the plates here shown were produced by discharges of minute quantities of electricity. From this point of view, they present a striking contrast to the plates published in THE CENTURY for June, 1900. Those were photographs of the phenomena resulting from discharges from electrical oscillators of great power. They recorded experiments made by that consummate genius of electrical investigation, Nikola Tesla, who delights in handling enormous quantities of electric energy.

By a cursory glance at the different plates and at the explanatory lines under them, it will be seen that whatever may be the outline of the entire design on the plate, there is one unvarying structural form for the positive phase and one for the negative. These are so dissimilar in character that they need never be confused. The positive phase has always the branching, fern-like structure which Mr. Kinraide calls filiciform, while the negative invariably shows the soft and feathery appearance which is well described as plumous. Whether the plate shows a single large disk composed of exquisitely delicate forms radiating from a center, or a series of zigzagging comets, one can readily tell by noting the structure whether the discharge which printed itself on the plate was in its positive or its negative phase.

This series of electrographs was, with a

few exceptions, produced by means of a condenser apparatus, upon one surface of which the sensitive plate was placed. This surface can be electrified either positively or negatively at the will of the operator. Suppose it to be negatively electrified, and then touched at the center by a small brass sphere which is in connection with the positive terminal of the apparatus. The instant discharge from the sphere rushes out in all directions over the surface of the plate, and there is produced the beautiful figure shown in Plate I. Suppose, on the other hand, that the condenser surface on which the sensitive plate rests is positively electrified, and that a brass sphere connected with the negative terminal be brought in contact with it. The energy is gathered up, as it were, from the plate, and rushing toward the conducting sphere, leaves on the surface the print of its vanishing footsteps, as in Plate II.

With one or two exceptions, all the plates here shown are based upon the existence of these two sets of conditions, i.e., a surface negatively electrified brought in contact with a positive terminal, and a surface positively electrified brought in contact with a negative terminal. The terminal may be connected with a single sphere, as already suggested, with a roller, or with tiny metallic balls or needle-points. The deft manipulation of these mechanical devices produces the variety of design. The plates which were produced under conditions other than these will be noted farther on.

It is now five years since Mr. Kinraide made the happy discovery which led him to experiment along the lines of electrical photography of which these beautiful plates are the result. The apparatus he at first used was quite unlike the one he is now using, and was without the condenser plates. Many of the results that can be obtained from the one now in use he was unable to obtain by means of the former, but untiring efforts to discover the causes of his failures finally brought a knowledge that enabled him to construct an apparatus capable of producing the perfect plates here shown. As in many other instances, failure lighted the way to success.

It is necessary to touch briefly on the construction of the apparatus and on the experiments carried on by means of it in order to give a clear idea of the way in which Mr. Kinraide has arrived at certain important conclusions. The apparatus has, as an interesting feature, a unique kind of secondary induction-coil consisting of a circular disk of fine wire wound in about one thousand turns. The peculiarity of this coil is that it will discharge out into the air as easily as the Ruhmkorff coil discharges toward its other terminal. In other words, the electric energy, instead of discharging from two equal potential terminals, as is the case where the Ruhmkorff coil is used, passes into the air almost wholly from one terminal. The non-discharging terminal is connected to an earth-wire, and thus its influence is entirely removed. The coil has a superb insulation, and will easily withstand a pressure under which the Ruhmkorff coil splinters to atoms. Thus the apparatus controls a higher voltage for the quantity than any other so far made.

It was while studying the discharge from this apparatus in the dark that Mr. Kinraide noticed peculiar, fern-like forms of a pale violet color radiating from the two-inch brass sphere which formed the discharging terminal. By manipulating the discharge, he could make a number of these beautiful, quivering forms appear. By using spheres of larger diameters and increasing the potential, he could increase the length and size of the light-forms until they would shoot out thirty inches beyond the sphere and reach an apparent thickness of half an inch. They looked like miniature forks of violet-tinged lightning, cleaving the darkness of the laboratory. By balancing an ordinary photographic plate on the top of the spherical terminal, film side down, and opening and closing the circuit once, a photograph of the quivering light-forms was secured. They recorded themselves as the filiciform or positive phase of electric energy. This was a first effort, and a first success.

Upon a reversal of the current, an entirely different phenomenon was observed. Instead of the branching outshoots of violet light, there appeared plume-like forms resembling the cattail of the meadow-flag. These seemed to be about an inch in diameter and seven inches long. An attempt to secure a photograph of these plume-like forms was made, but though the plate was as carefully adjusted and the current as skilfully manipulated as before, there was no record found upon the plate when it was developed. The experiment was repeated again and again, but with disheartening results. The plumous forms could not be induced to make any impression on the sensitive plates. For two years Mr. Kinraide experimented, sacrificing plates enough to build a greenhouse. Then he made a discovery. The plumous

forms were not, as he had supposed, discharging outward from the sphere; they were discharging inward from the surrounding air.

The discovery of this fact was of the greatest significance. It seemed to proclaim electric energy not a dual force with a dual activity, but a single force with a single line of direction for the sweep of its energy. Furthermore, it showed plainly that the so-called positive and negative phenomena indicate, the one an accumulation or heaping up of electric energy, the other a corresponding withdrawal. It was through study of the plumous forms that Mr. Kinraide was led to the discovery of the conditions necessary for the successful production of these photographs. He realized that, in order to secure on a photographic plate the record of the so-called negative electricity, the plate must represent the withdrawal of energy; in other words, it must be electrified and then made to discharge itself into some conductor.

With the condenser apparatus, he found no difficulty in securing the record of the negative phase. A photographic plate placed upon the positively electrified surface of the condenser became in turn positively electrified. Then, when any conductor connected with the negative terminal was brought into contact with it, the stored-up energy immediately sought an equilibrium and rushed from all directions toward the conductor. This produced a condition of withdrawal on the plate, or, in other words, showed the so-called negative phase of electricity.

It was then that Mr. Kinraide made another discovery. Not only did he secure photographs of the positive and negative phases, but there was revealed on some of the plates the existence of comet-like forms in which the positive and negative were seen to be united, base to base. The meaning of these comet forms was not at first understood, nor did Mr. Kinraide know how it was that they appeared on the plates. Former photographs had indicated a separation between the two phases; none had ever shown that they were united. These comet forms, therefore, presented a new field for investigation, and it was only after careful study and experimentation that their significance was discovered.

The comet structure Mr. Kinraide has called, by reason of the conditions under which it is created, the electric entity. It is a record of the entire activity of one small quantity of electric energy, an embodiment, as it were, of the force, and literally an entity of energy, having a birth, a growth, and a subsequent death or dispersion. Its center, or body part, is plainly neither positive nor negative in character. Mr. Kinraide calls it the third or dynamic phase of electricity. His reasons for this will be apparent farther on.

In order to make clear the way in which the comet structure was secured, it may be well to explain first the development of the figure on Plate III. This is not one of the condenser series of photographs, but was secured from a very different and quite simple apparatus. It is introduced here to make clearer the interpretation of the other plates.

Without describing the apparatus in detail, it is sufficient to say that it presented a flat surface about twice as long as wide. This surface was divided by a narrow strip of dielectric or non-conducting material into two areas of equal extent, each of these being nearly square. The apparatus was so arranged that when the current was turned on, one of these areas would become positively, the other negatively electrified, the dielectric between them preventing the energy from reaching a state of equilibrium.

The photographic plate was placed in position on the flat surface, half of it on one side of the dielectric, half on the other. A metallic bar was then laid upon the plate at right angles to the dielectric. Thus its ends lay at the respective centers of the two areas which were to be oppositely electrified. By closing the current and then breaking it once, Plate III was obtained. The two ends of the photographic plate became oppositely electrified, like the areas over which they were superimposed. When the current was broken, the energy in the two oppositely electrified surfaces immediately rushed to an equilibrium, using the metallic bar as a conductor. From the positively electrified surface the energy shot into the bar, recording its withdrawal in the delicate plumes of the negative phase. Then it hurried along and finally shot out and dispersed itself over the negatively electrified surface in the filiciform streamers, which always indicate the outward rush of the current.

In the evolution of the comet structure, analogous conditions obtain, with the exception that the electric energy uses the air as a conducting medium instead of a metal conductor. This enables it to record the entire history of its action on the sensitive plate. Keeping this explanation in mind, the reader will be able to understand Plate IV, which is one of the condenser series.

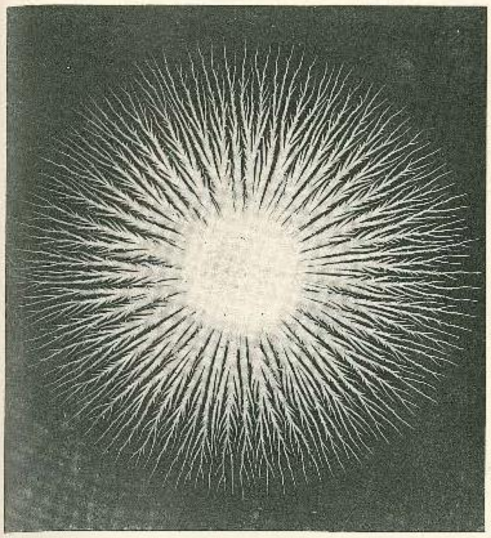


PLATE I. ANODOS.

A discharge of electric energy over the negative surface of a condenser *from* a two-inch sphere connected with the positive terminal.

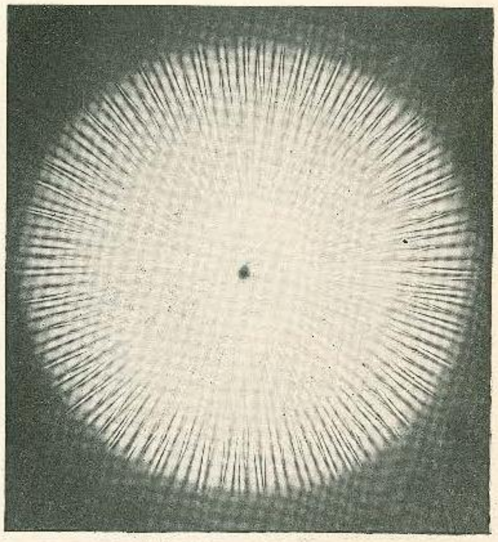


PLATE II. KATHODOS.

A discharge of electric energy over the positive surface of a condenser *toward* a two-inch sphere connected with the negative terminal.

In order to secure this, the condenser surface upon which the sensitive plate was to be placed was first highly charged with electric energy. Then the photographic plate was carefully placed upon it, film side up. A metallic discharger, fitted with an adjustable spark-gap, was now used. By means of this spark-gap it was possible to regulate the amount of energy to be withdrawn from the plate. After being connected with the negative terminal of the apparatus, the discharger was placed at the center of the plate, and a small quantity of the energy was permitted to escape. This created a circular, negative area on the plate, while surrounding it was a charged area.

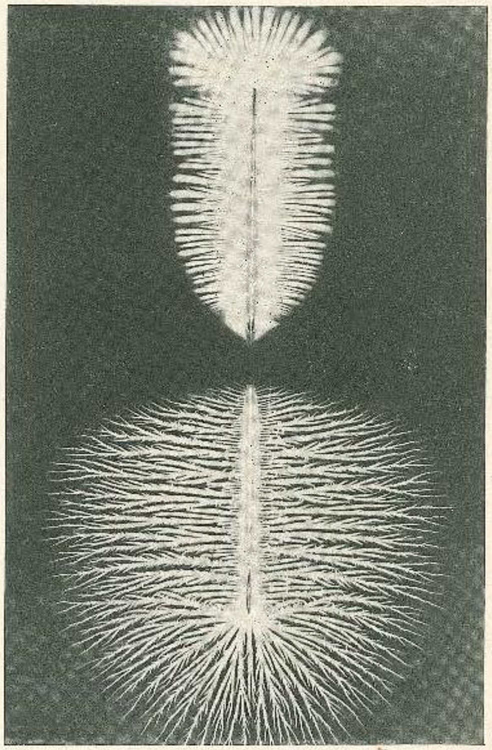


PLATE III. COMPOSITE ELECTRIC ENTITY.

A transfer of electric energy produced by placing a short, metallic rod across the line dividing two oppositely charged areas. The part of the plate upon which the plumous or negative phase is seen is the part which was at first positively electrified. The part upon which the positive streamers are seen was the negatively electrified areas.

As in the case of the two oppositely electrified squares previously referred to, the energy sought an equilibrium. Small quantities of it shot inward toward the circular, negative area, and the onward rush was recorded on the plate in the filiciform streamers extending toward the center, while the withdrawal from the outer rim produced the soft plumous forms. All this took place before the discharger in the operator's hand could be withdrawn from its instant of contact with the plate.

The energy started from a condition of diffusion, and ended in a condition of diffusion, but at the instant of its greatest power it was focalized. This instant of focalization is represented on the plate by the slender spindle joining the plumous and the filiciform. This is what Mr. Kinraide calls the dynamic phase of electric energy.

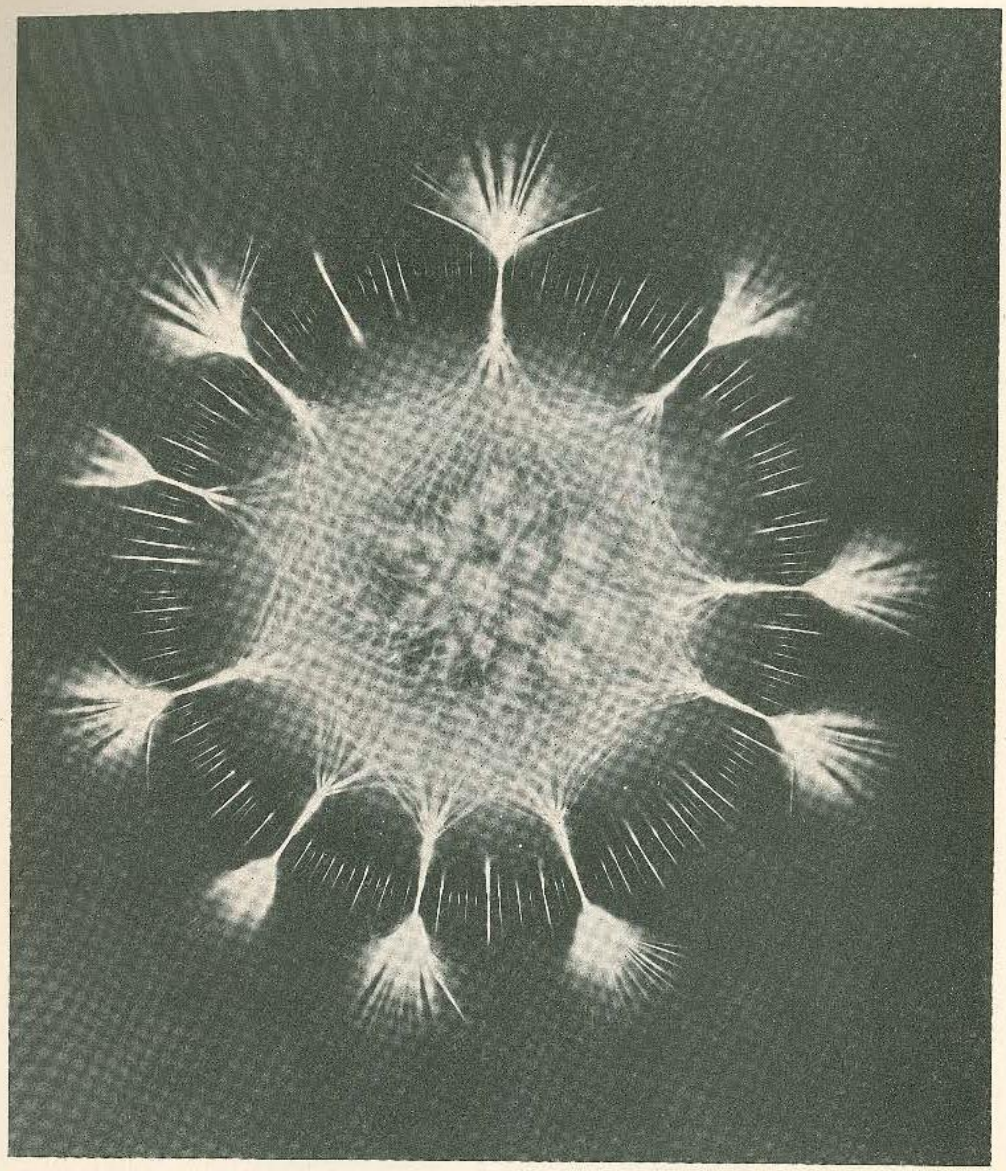


PLATE IV. SYMMETRICAL GROUP OF ELECTRIC ENTITIES.
Each comet structure in the group is a record of the entire history of a small quantity of electric energy.

In general terms, the spindle of one of these comet structures represents the dynamic center of a discharge, for each tiny comet records the entire evolution of an electric discharge, and the phases through which it passes are identical with those through which every uninterrupted discharge must pass.

That this spindle has never before been shown in any photographs of electricity is due to the fact that no apparatus has ever before been constructed whereby the entire action of an electric discharge through the air could be recorded. In the action of the energy in Plate III its moment of greatest focalization was during its passage through the metallic bar. Hence its form could not be recorded.

Examine for a moment this spindle (see Plate V). It seems to be wound in a conical spiral, as if the lines of energy, which focalize at the point of greatest intensity, assume at once a spiral motion. This spiral whirl is at first very narrow, but as it passes away from the point of greatest intensity, it becomes wider, and its whirls are farther apart. Under favorable conditions they are far enough apart to be seen, forming a sharply pointed cone with a very small base. Thus it seems

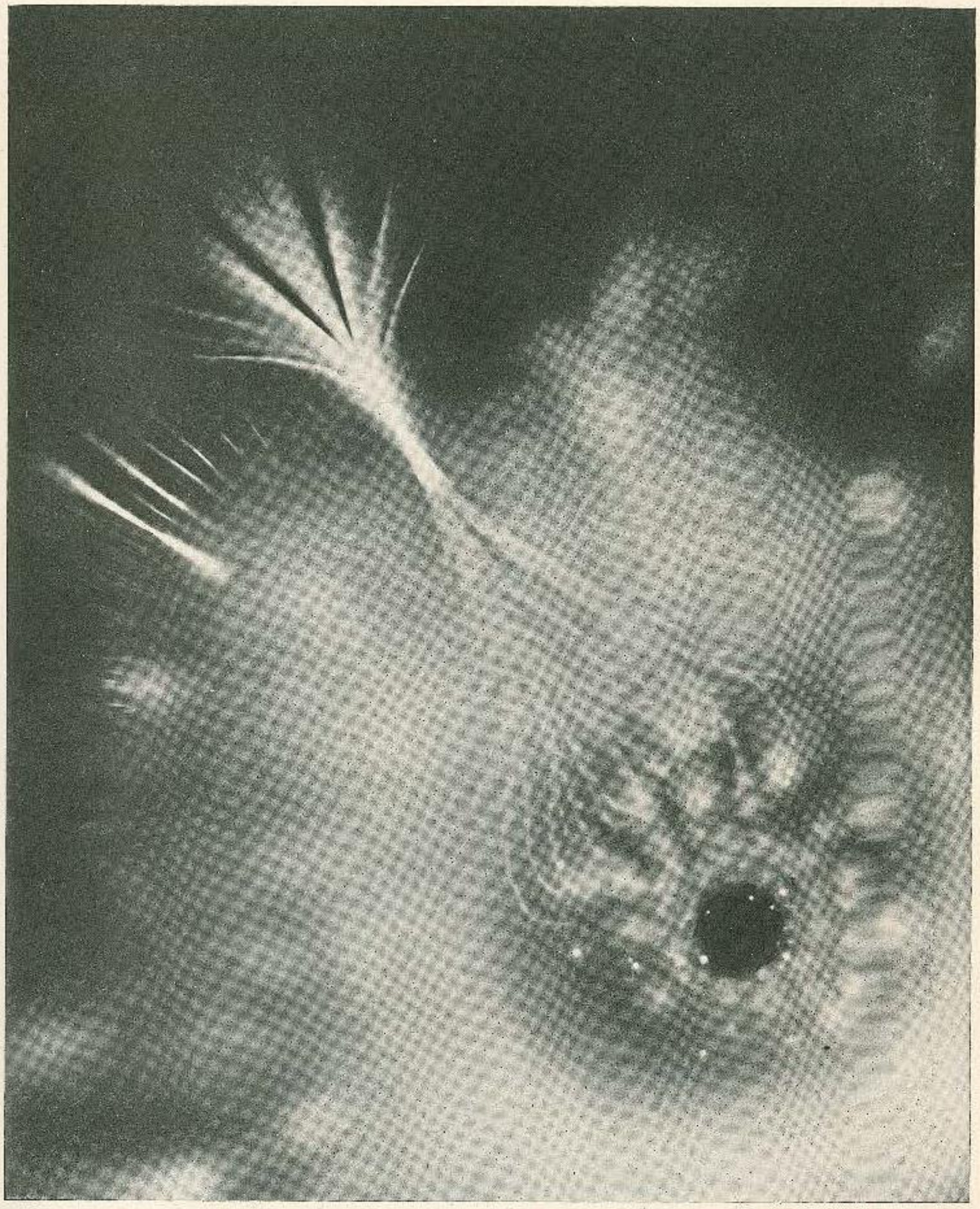


PLATE V. ELECTRIC ENTITY, OR EMBODIMENT OF ELECTRIC FORCE. (ENLARGED.)

that the electric energy focalizing at this point translates itself, by means of the electromagnetic action which takes place in the spindle, from its negative phase into a curiously interacting form, the positive phase.

Mr. Kinraide's conclusions may be summarized as follows: The plates here shown, especially those which record the action of the electric entity, form an electrographic demonstration of the meaning of the terms positive and negative electricity. When electric energy changes from a condition of diffusion to a center of focalization it is passing through its negative phase. When it changes from a condition of focalization to a condition of diffusion it is passing through its positive phase. These two conditions may be correctly termed the anodos, or going in, and the exodos, or going out, of electric energy. They are unmistakably recorded on the photographic plates, which show that there are not two separate electricities, but one developing entity of energy. There is no photograph of the diffused condition in either case. It is only when the energy is passing through one or the other



PLATE VI. POSITIVE ENDS OF ELECTRIC ENTITIES.

A discharge from a metallic roller in its passage over the film side of a photographic plate placed upon the uncoated, negative surface of a charged condenser. The conditions of electrification here are the opposite of those in Plate VII.

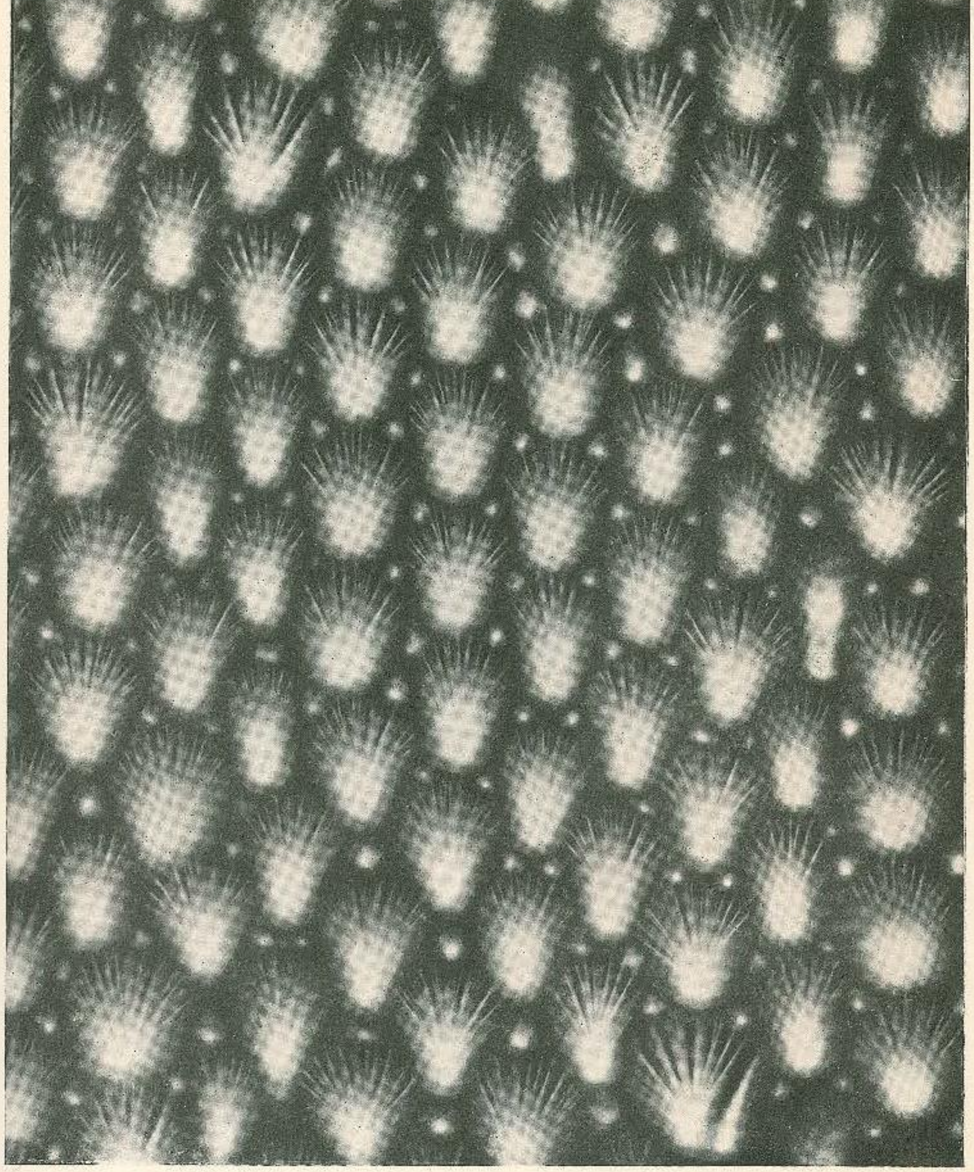


PLATE VII. NEGATIVE ENDS OF ELECTRIC ENTITIES.

A discharge from a metallic roller in its passage over the film side of a photographic plate placed upon the uncoated, positive surface of a charged condenser. This plate is a companion to Plate VI.



PLATE VIII. ELECTRIC ENTITIES IN SERIES.

A discharge between plates produced by the passage of a metallic roller over a photographic plate laid film side down upon a positively charged, uncoated condenser surface.

of its three phases that it becomes manifest upon the sensitive plate.

Plate V is an enlarged record of one small quantity of electric energy: its origin, or negative phase; its transformation, or dynamic phase; its final diffusion, or positive phase. In the negative phase the energy consists of numerous units of energy uniting to produce a single unit, which, after spiraling through a small space, is changed into a number of streamers to be again diffused.

Plates VI and VII, which show respectively the positive and negative ends of electric entities, belong to the condenser series. As explained in the lines under them, they were secured by means of a roller passing over the surface of the photographic plate. Plate VI shows the outrushing or positive ends of the tiny entities that shoot off from the roller on to the negatively electrified plate as the roller is passed over the plate. Plate VII shows the retreating or negative ends of the entities that rush from the positive plate into the negative roller.

Plate VIII shows how comets in series are formed when the energy *between* condenser surfaces is permitted to escape into a metallic roller passed over the outer surface of the plate. This was secured by placing the photographic plate film side down.

The photographs here reproduced form a representative selection from many hundreds secured by Mr. Kinraide. They are much reduced in size, the negatives being eighteen by twenty-two or eight by ten inches. A set consisting of about fifty photographs has recently been presented to the Massachusetts Institute of Technology, where it is available to students and other interested persons.

The conclusions as to the nature of electricity reached by Mr. Kinraide through his study of its movement differ to a considerable extent from those reached by Lord Armstrong, the noted English scientist who

has conducted experiments along similar lines. Lord Armstrong has secured some extremely interesting photographs of the phenomena resulting from discharges of electricity over dust plates. He has also experimented with photographic plates, and a number of the results secured in both cases bear an interesting resemblance to those obtained by Mr. Kinraide. Lord Armstrong has not, however, shown the development of the electric entity.

It may be interesting to add that, as a result of his study of electric energy as manifested in these plates, Mr. Kinraide inclines to the theory that every form of energy, as heat, sound, light, gravity, etc., has what he would term an entity of energy, corresponding in structure and function to the electric entity, and that it only requires a knowledge of how to create conditions in order to demonstrate this.

He asks the interesting questions: "May it not be that the whirlwind and the water-spout proclaim the presence of entities of thermal energy, the whirlpool the presence of an entity of gravity, and the sound-waves recently photographed the presence of the entity of sound force?" He maintains, also, that if the conditions are constant, the entity will be constant. *A prime condition must be that the energy be able to mold the substance which is the medium of its manifestation into its own form.* Its power to do this demonstrates that it is a force-entity. Mr. Kinraide proposes to experiment with other forms of energy and to obtain, if possible, a complete demonstration of this theory.

THE PASSING OF COCK-EYE BLACKLOCK.

BY FRANK NORRIS,

Author of "The Octopus," etc.

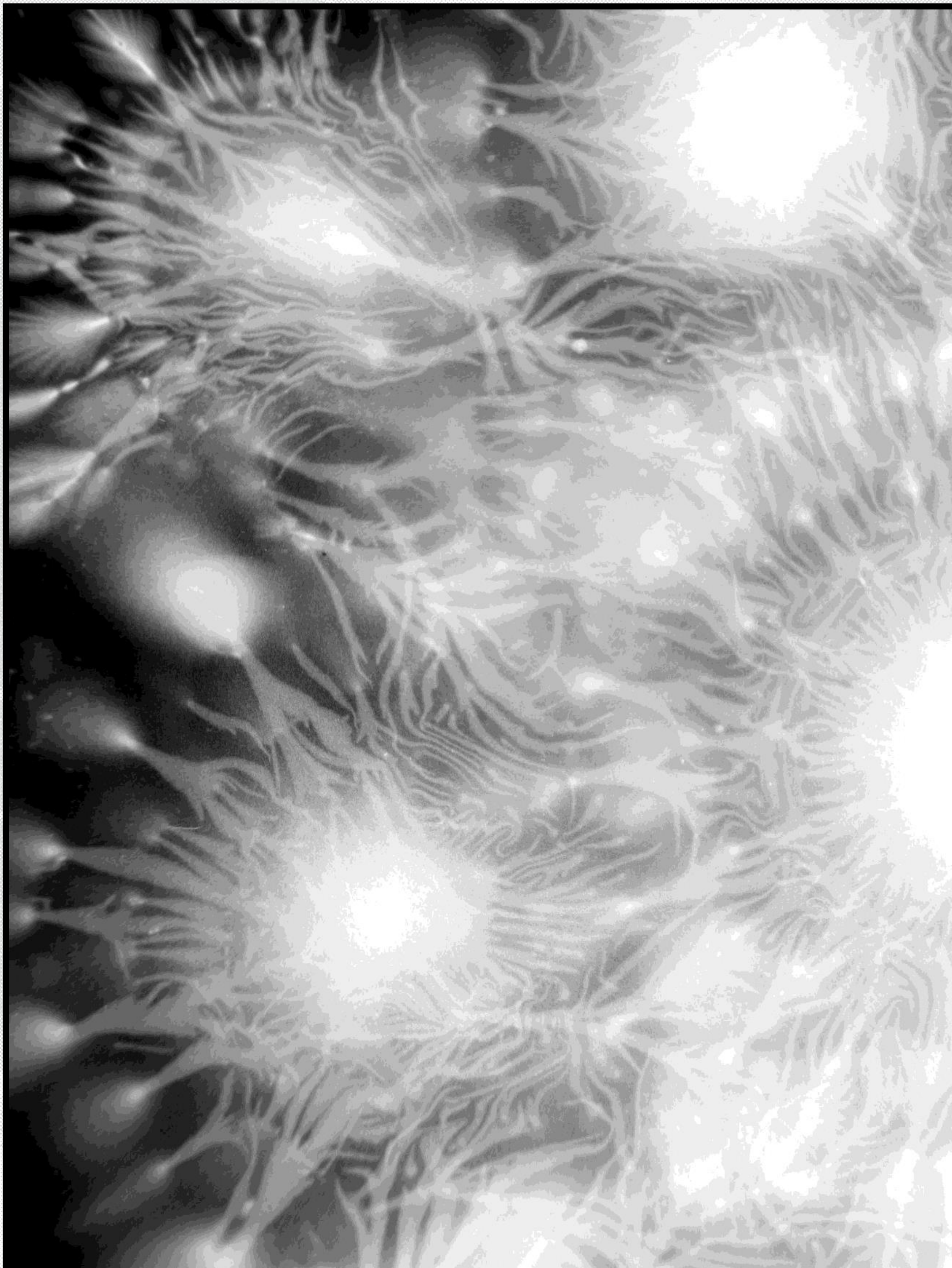
"WELL, m' son," observed Bunt about half an hour after supper, "if your provender has shook down comfortable by now, we might as well jar loose and be moving along out yonder."

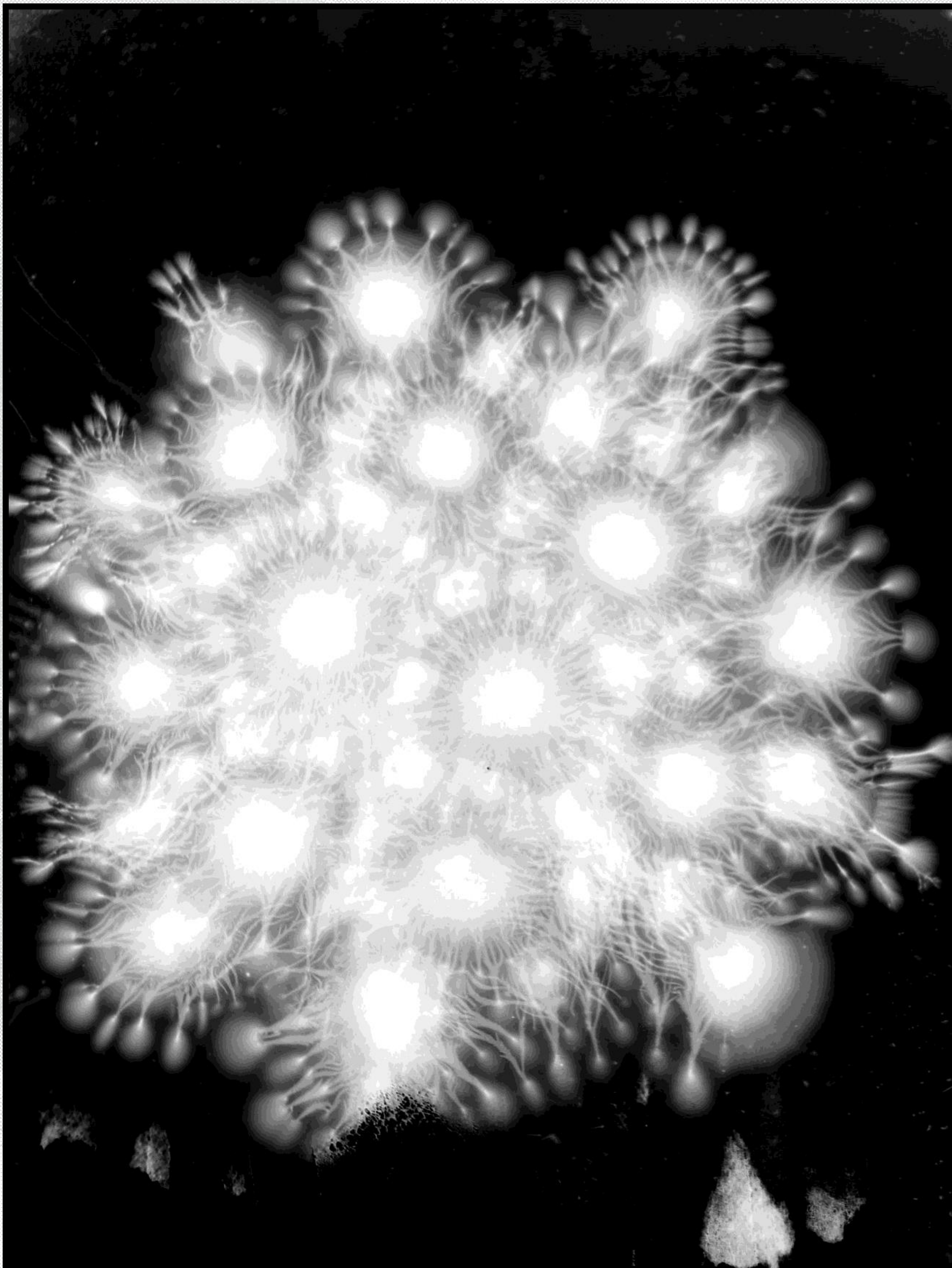
We left the fire and moved toward the hobbled ponies, Bunt complaining of the quality of the outfit's meals. "Down in the Panamint country," he growled, "we had a Chink that was a sure frying-pan expert; but *this* Dago—my word! That ain't victuals, that supper. That 's just a' ingenious device for removing superfluous appetite. Next time I assimilate nutriment in this camp I 'm sure going to take chloroform beforehand. Careful to draw your cinch tight on that pinto bronc' of yours. She always swells up same as a horned toad soon as you begin to saddle up."

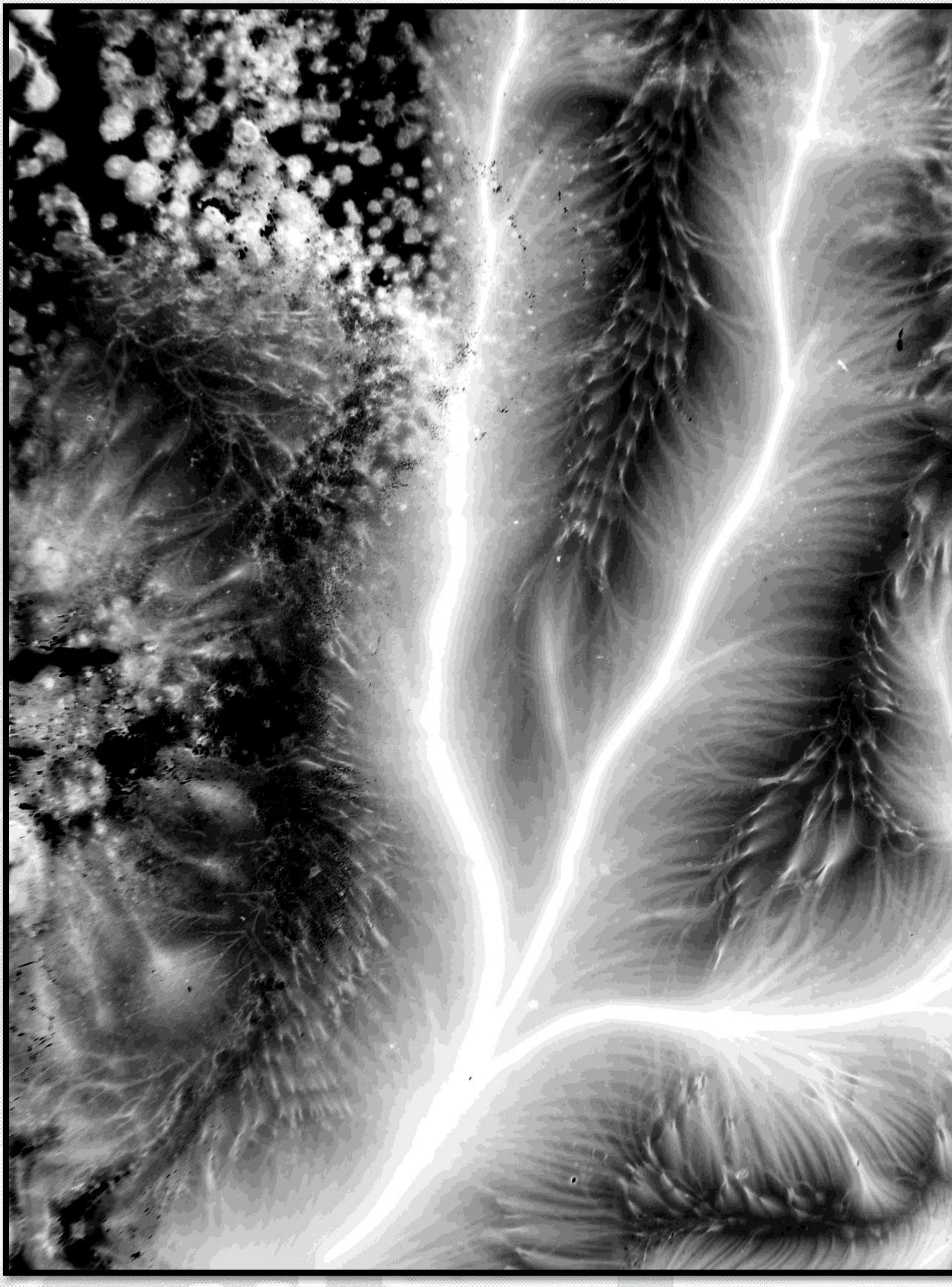
We rode from the circle of the camp-fire's light and out upon the desert. It was Bunt's turn to ride the herd that night, and I had volunteered to bear him company.

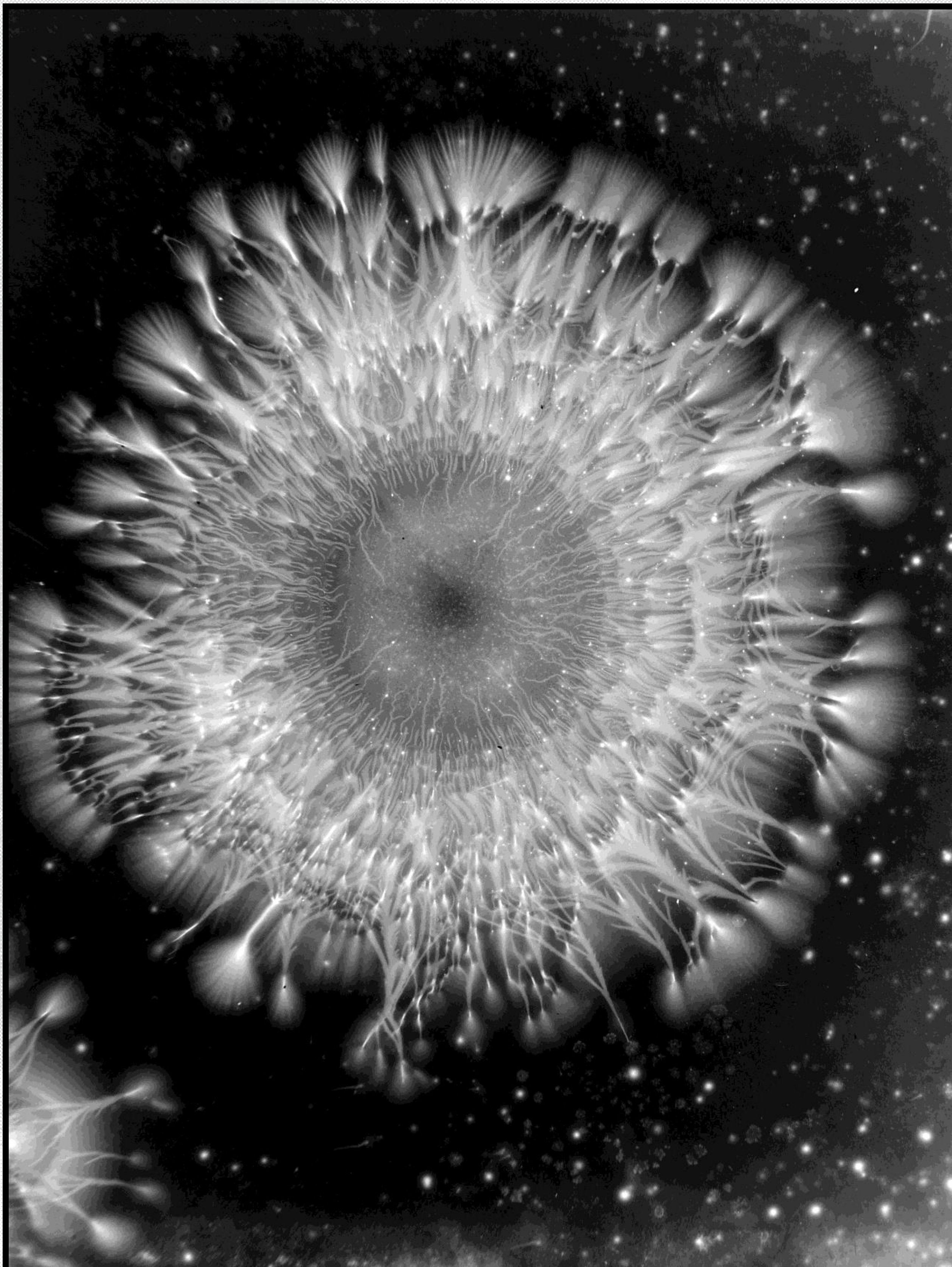
Bunt was one of a fast-disappearing type. He knew his West as the cockney knows his Piccadilly. He had mined with and for Ralston, had soldiered with Crook, had turned cards in a faro game at Laredo, and had known the Apache Kid. He had fifteen separate and different times driven the herds from Texas to Dodge City, in the good old, rare old, wild old days when Dodge was the headquarters for the cattle trade, and as near to heaven as the cow-boy cared to get. He had seen the end of gold and the end of the buffalo, the beginning of cattle, the beginning of wheat, and the spreading of the barbed-wire fence, that, in the end, will take from him his occupation and his revolver, his chaparejos and his usefulness, his lariat and his reason for being. He had seen the rise of a new period, the successive stages of which, singularly enough, tally exactly with the progress of our own world-civilization: first the nomad and hunter, then the herder, next and last the husbandman. He had passed the mid-mark of his life. His mustache was gray. He had four friends—his horse, his pistol, a teamster in the Indian Territory Panhandle named Skinny, and me.

The herd—I suppose all told there were some two thousand head—we found not far from the water-hole. We relieved the other watch and took up our night's vigil. It was about nine o'clock. The night was fine, calm. There was no cloud. Toward the middle watches one could expect a moon.

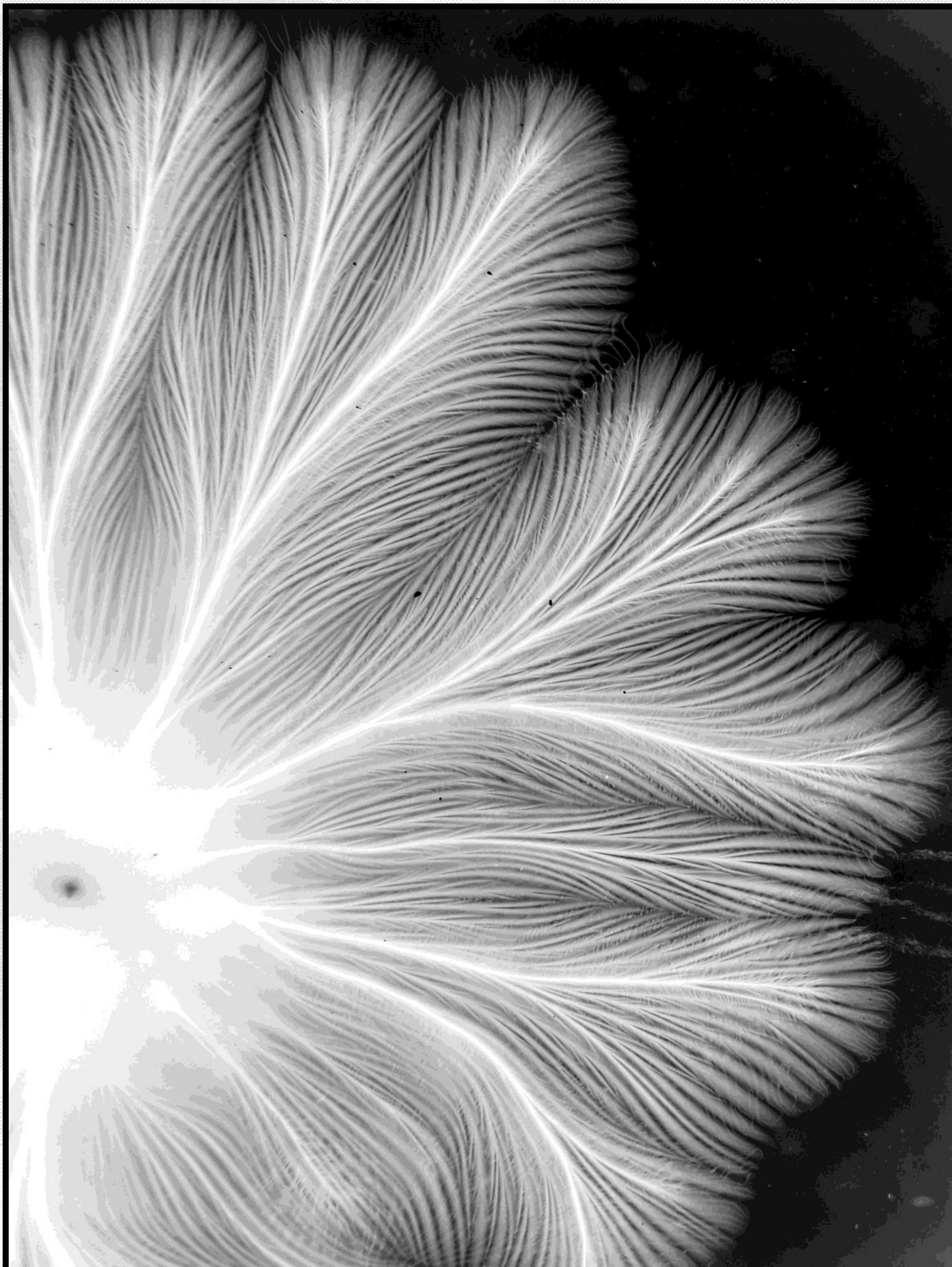


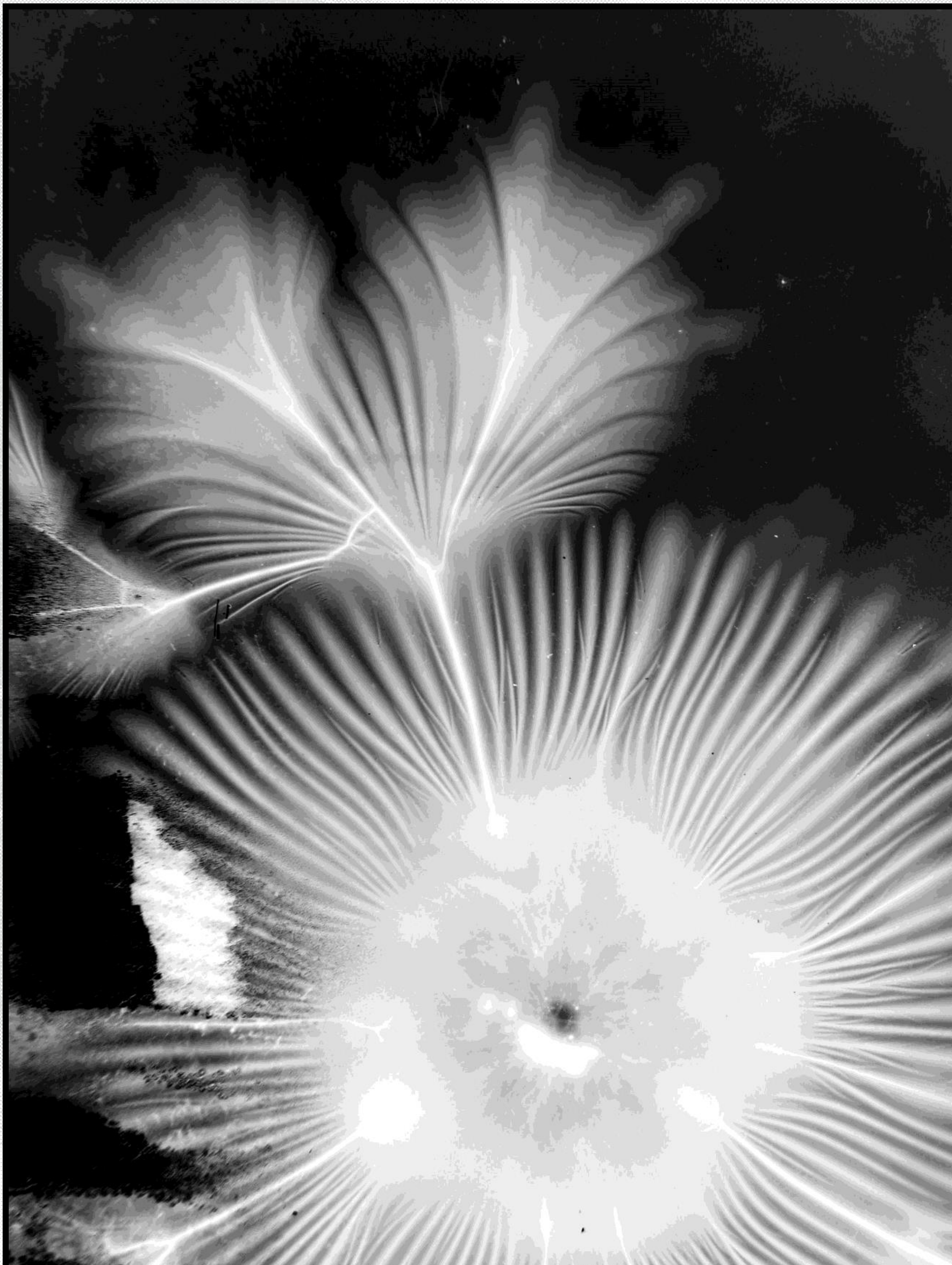


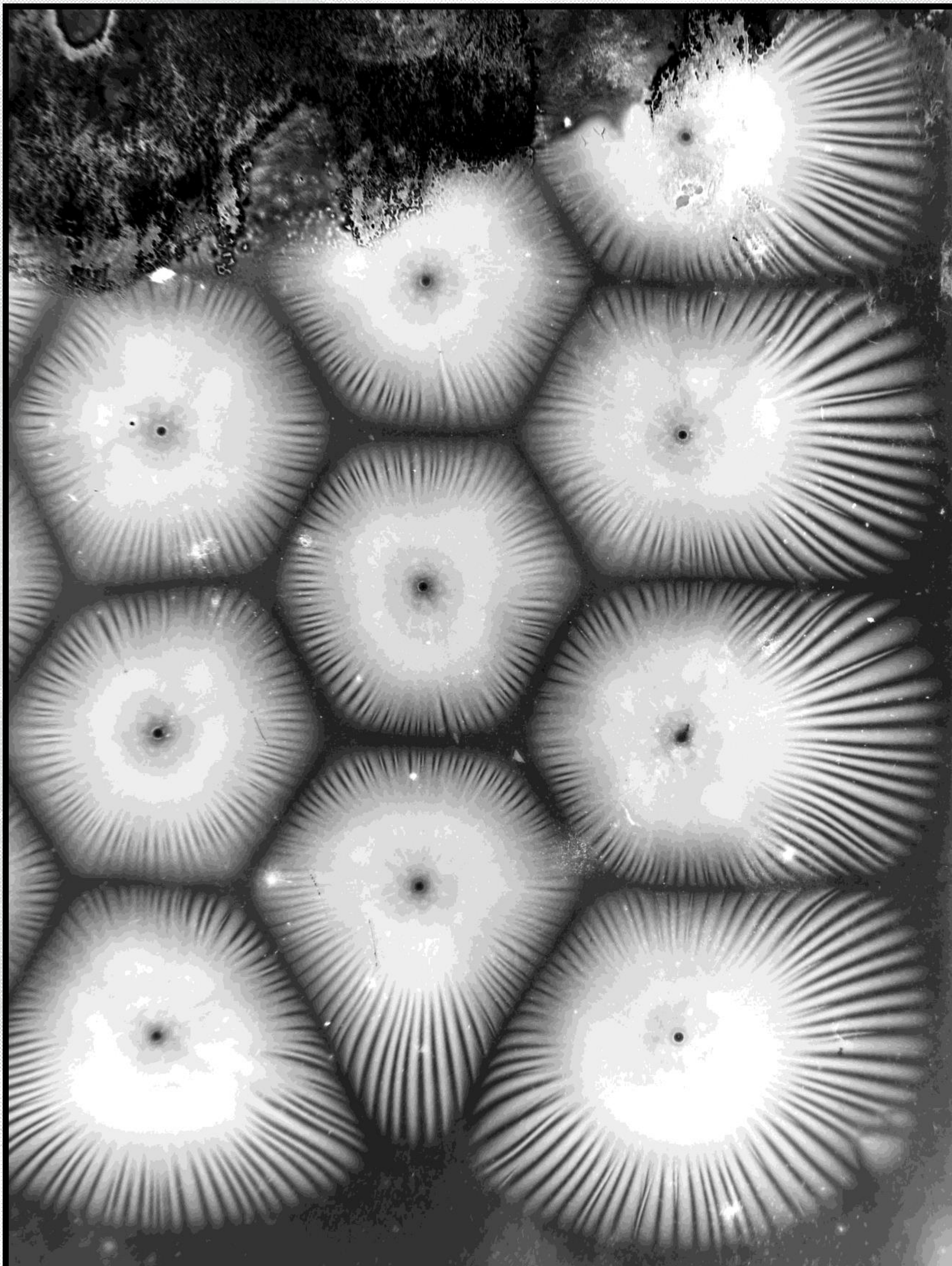


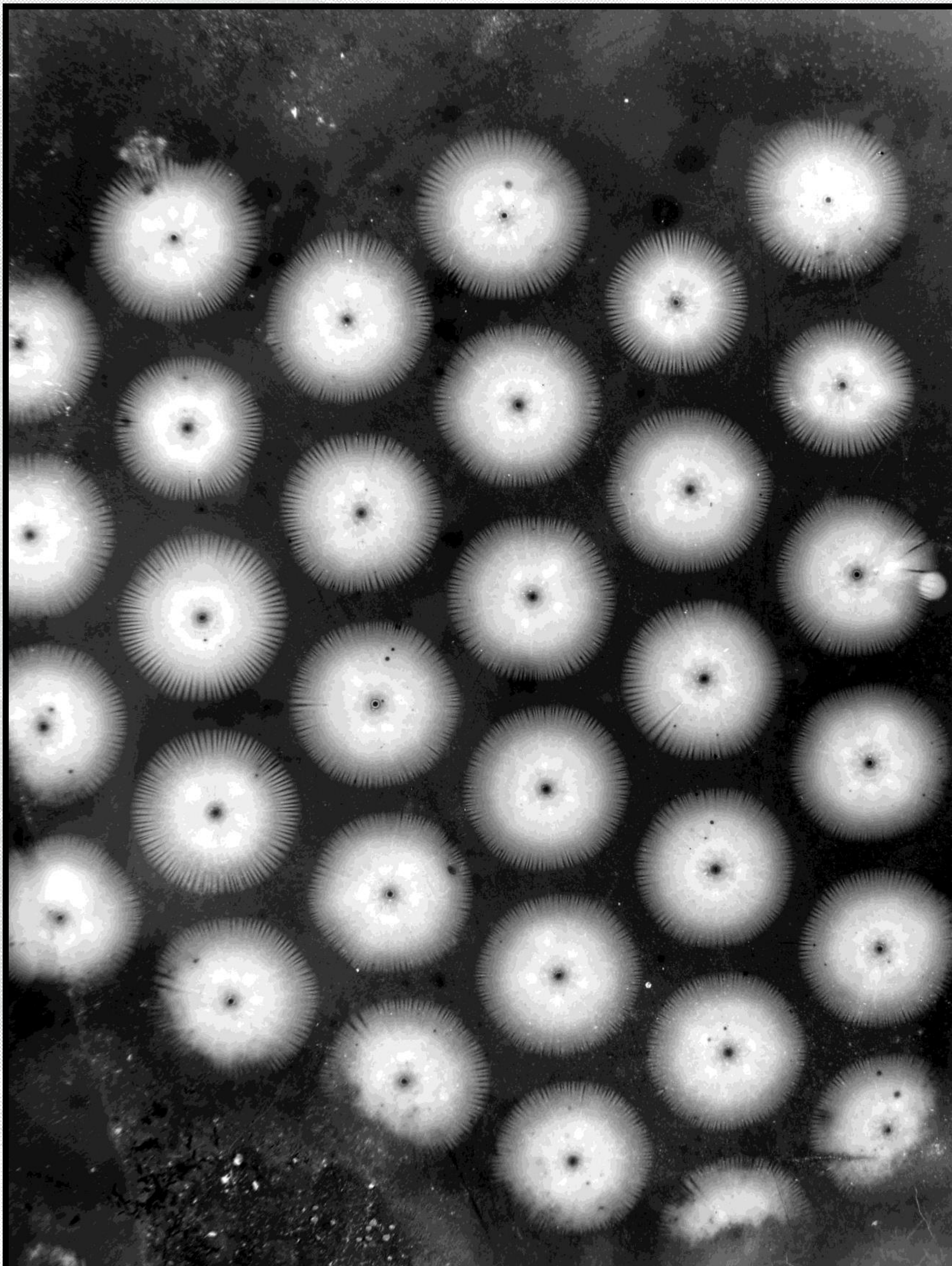


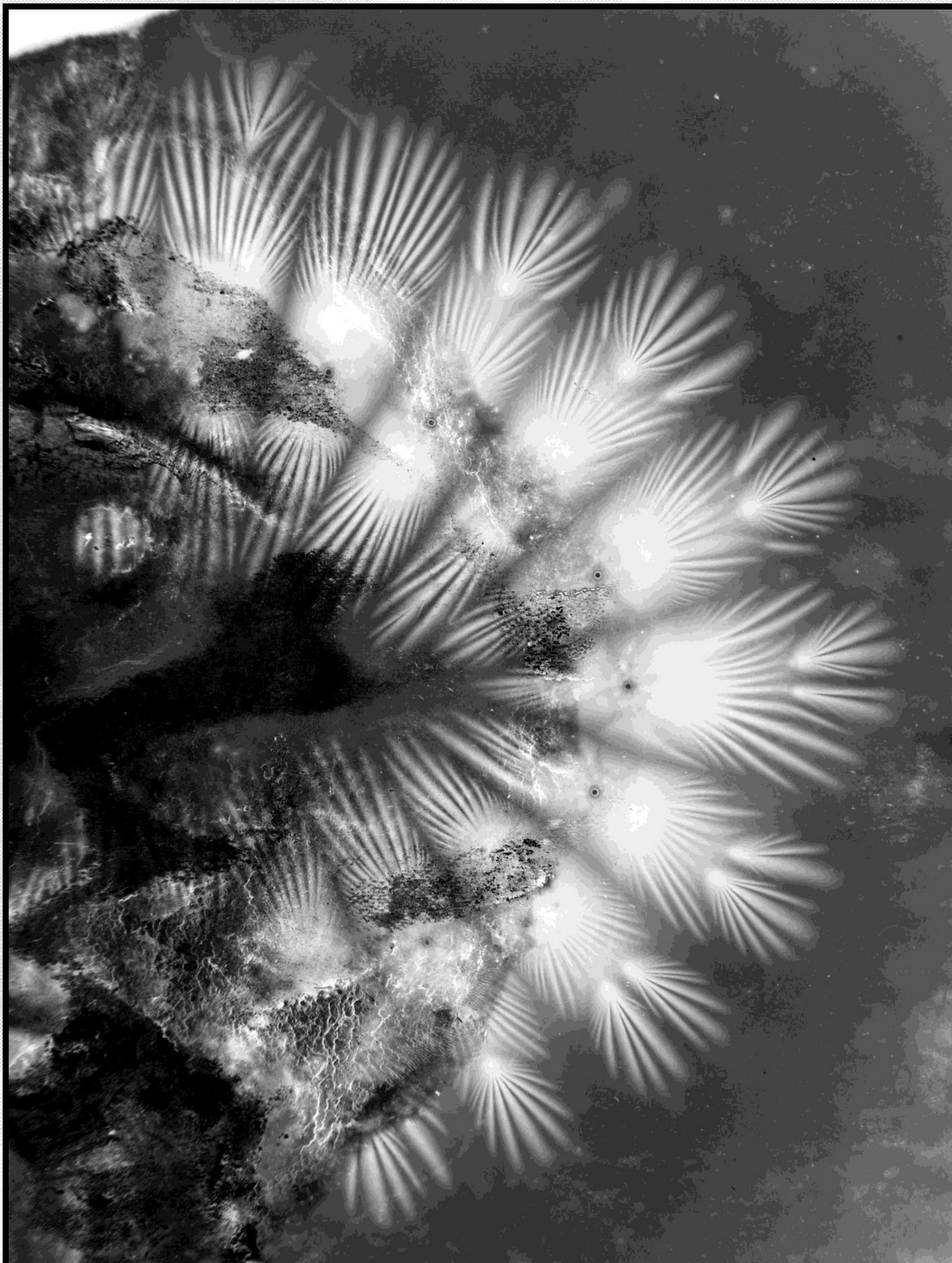


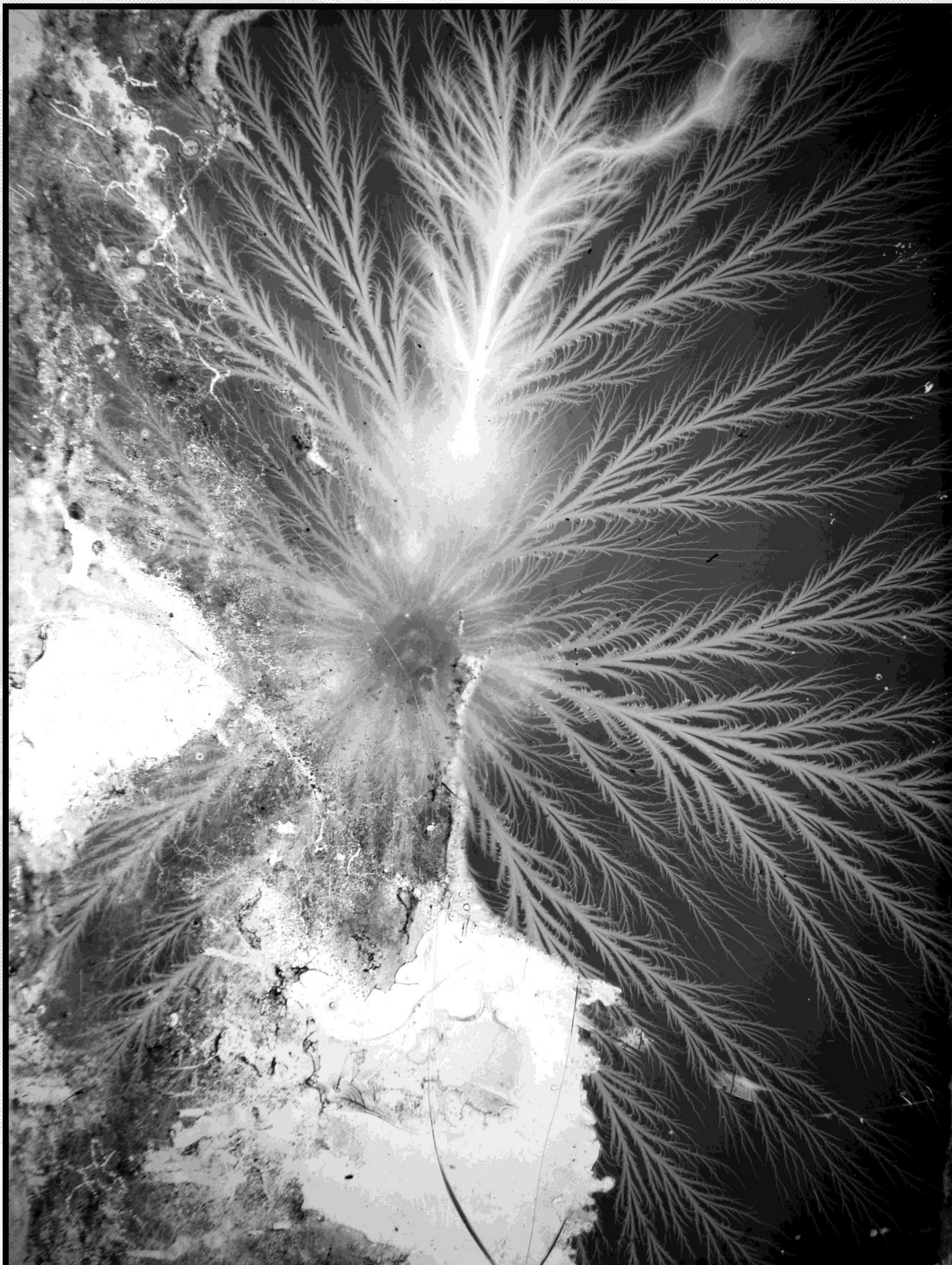








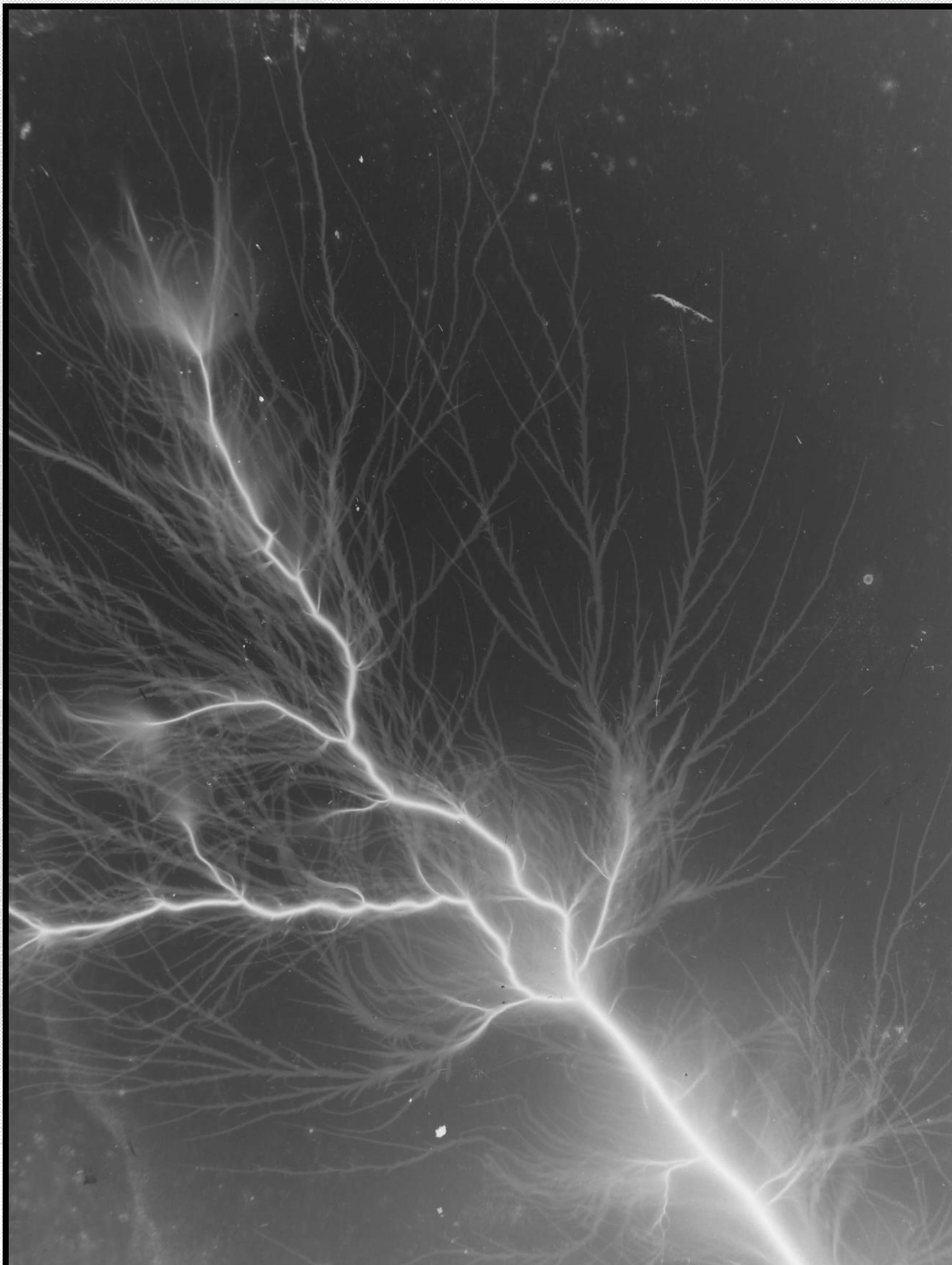


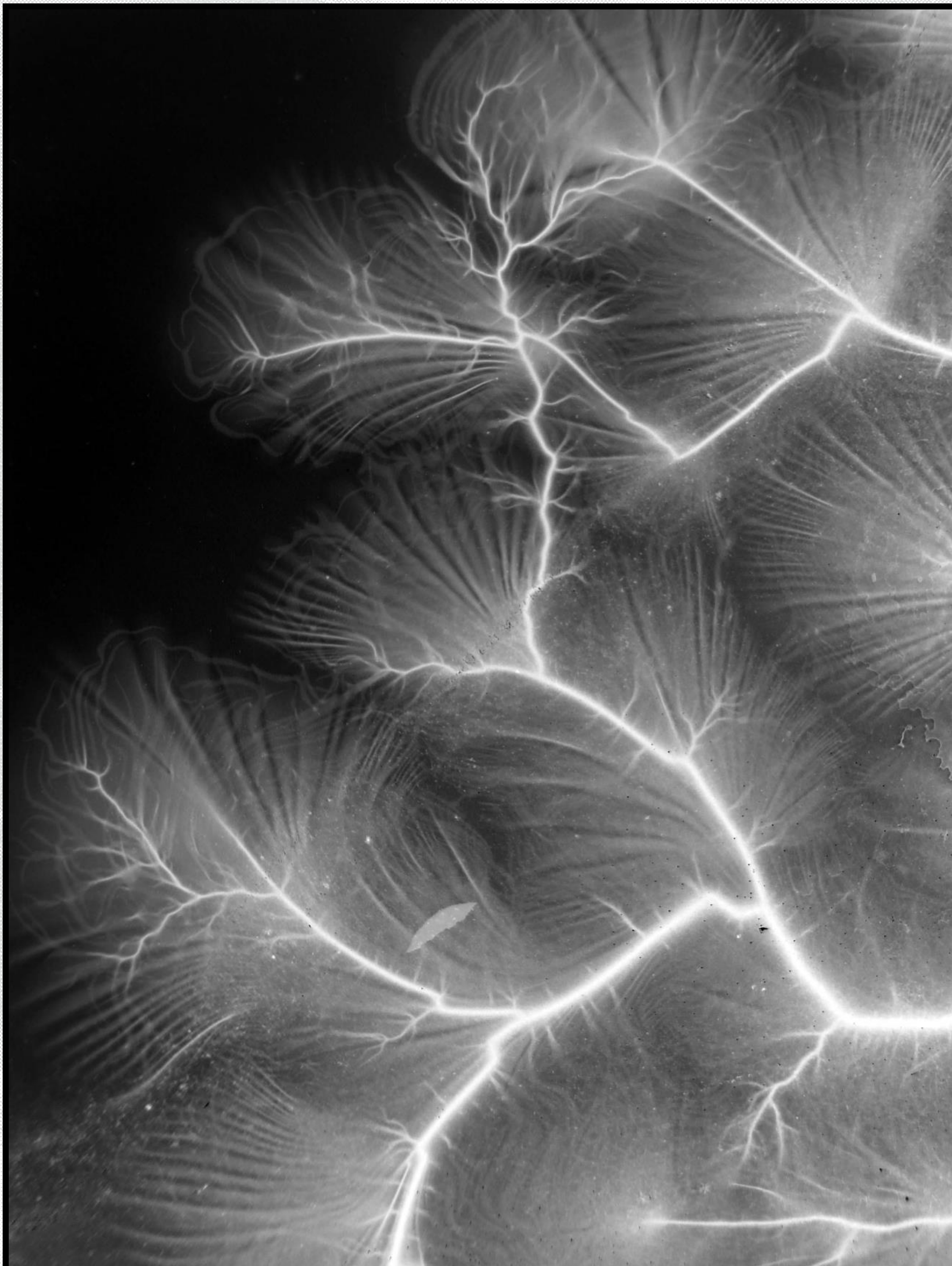


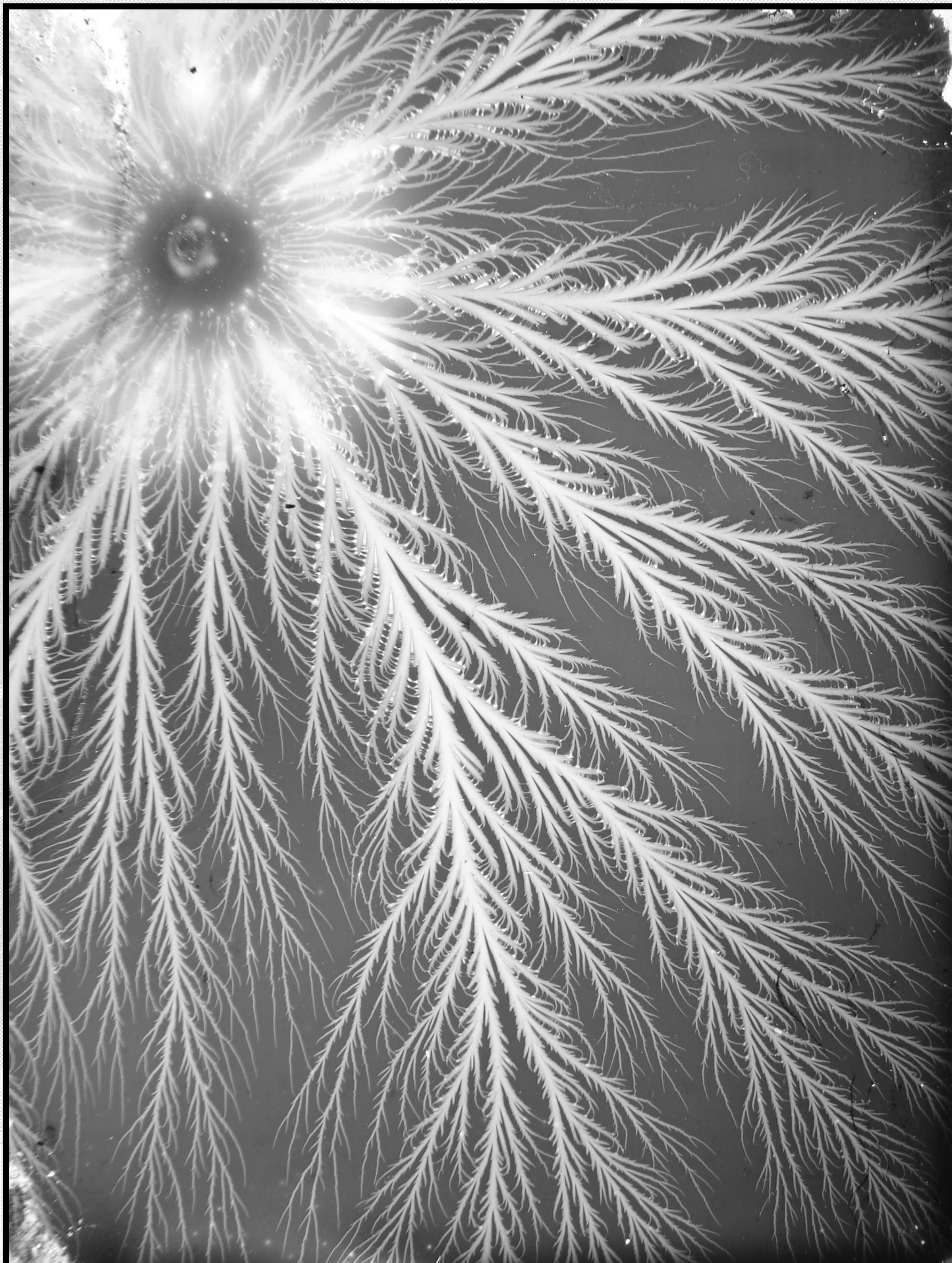


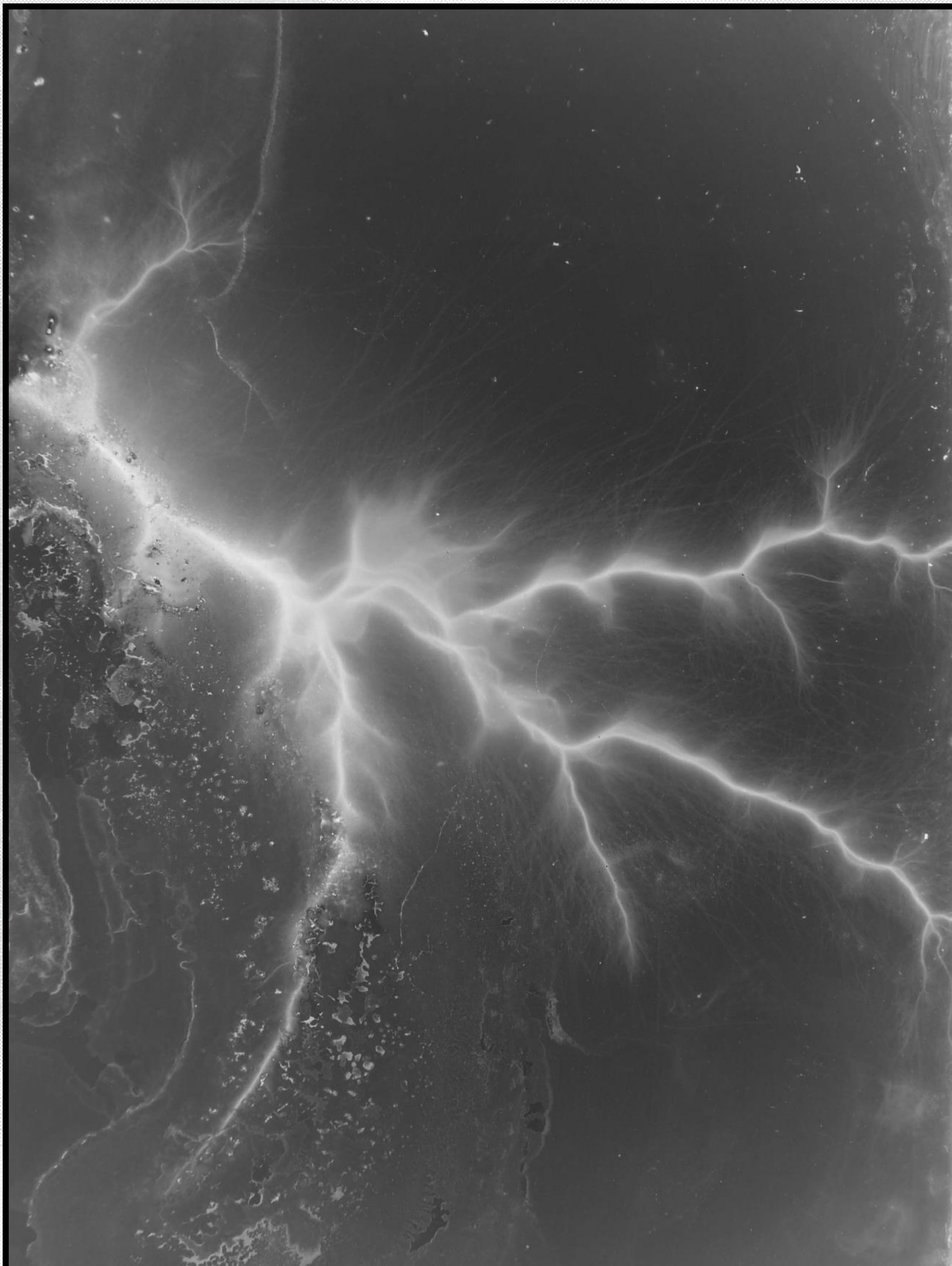




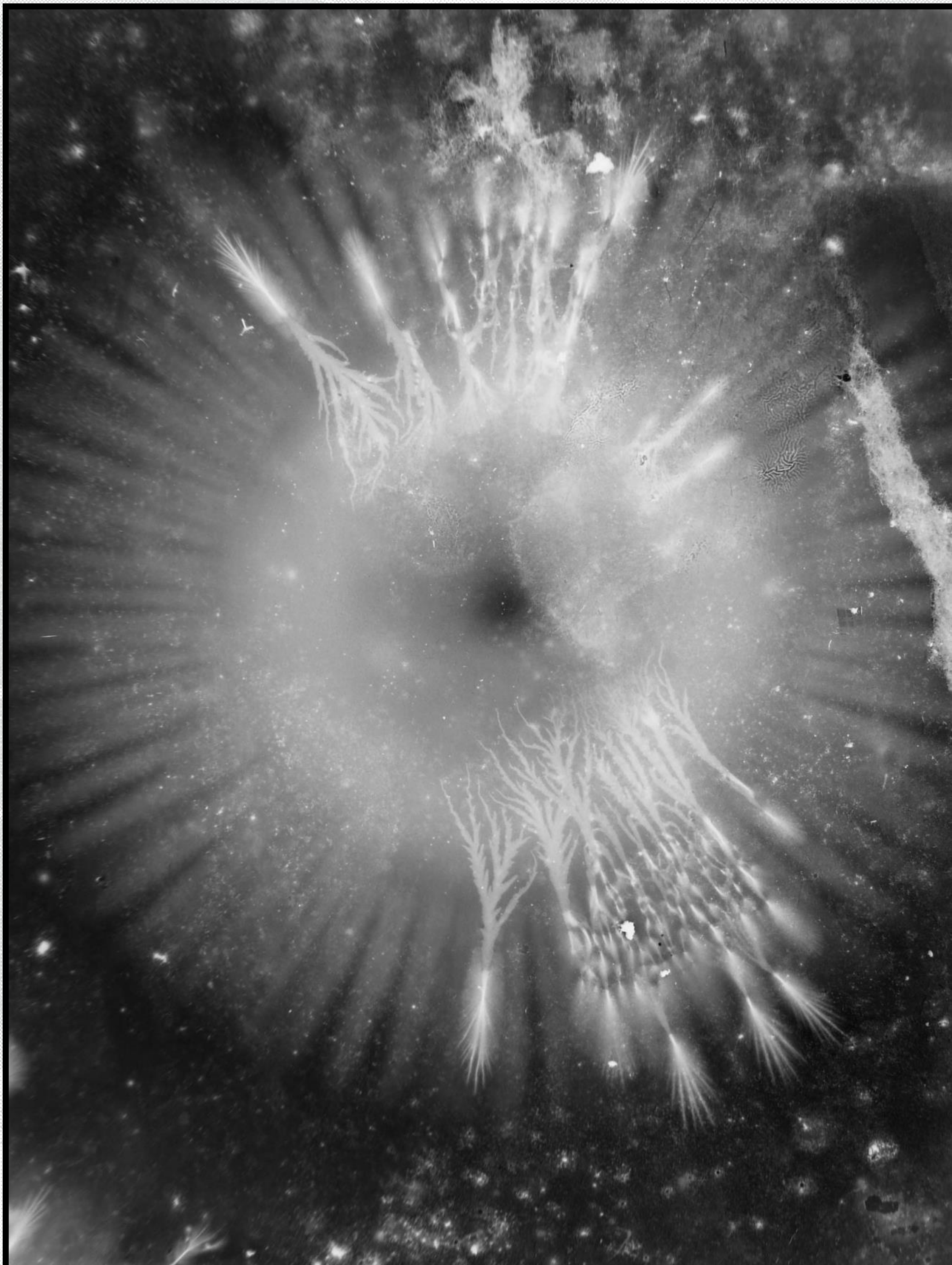


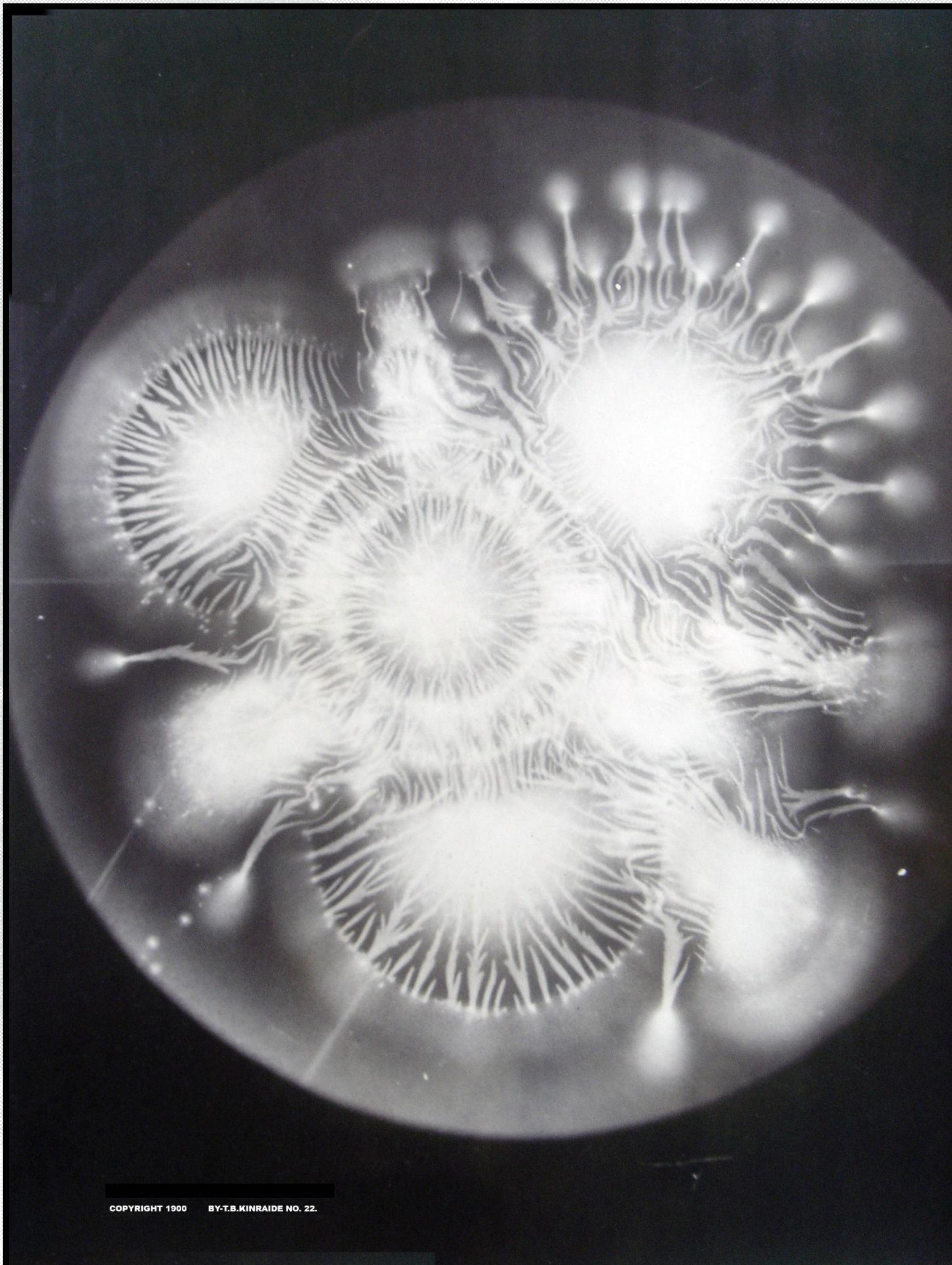











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BY-T.B.KINRAIDE.NO. 36.
No. 36.
THE ENTITY OF ELECTRICITY.
(Enlarged)
The embodiment of the triple Phase of Electricity. An autographic record of a developing entity of energy. Its Focalization or negative phase; its dynamic or magnetic phase; its diffusion or Positive phase.
The withdrawal of electricity from a portion of a charged condenser surface produces a negative condition relative to the rest of the surface. The Electric force in its change from the Positive to the Negative condition causes the developement of the Electric entity. The Negative phase of the entity has its origin and end on the Positive, whilst the Positive phase begins and ends in the negative condition of the plate's surface. The dynamic or magnetic unites the two opposites phases.
Condenser Series

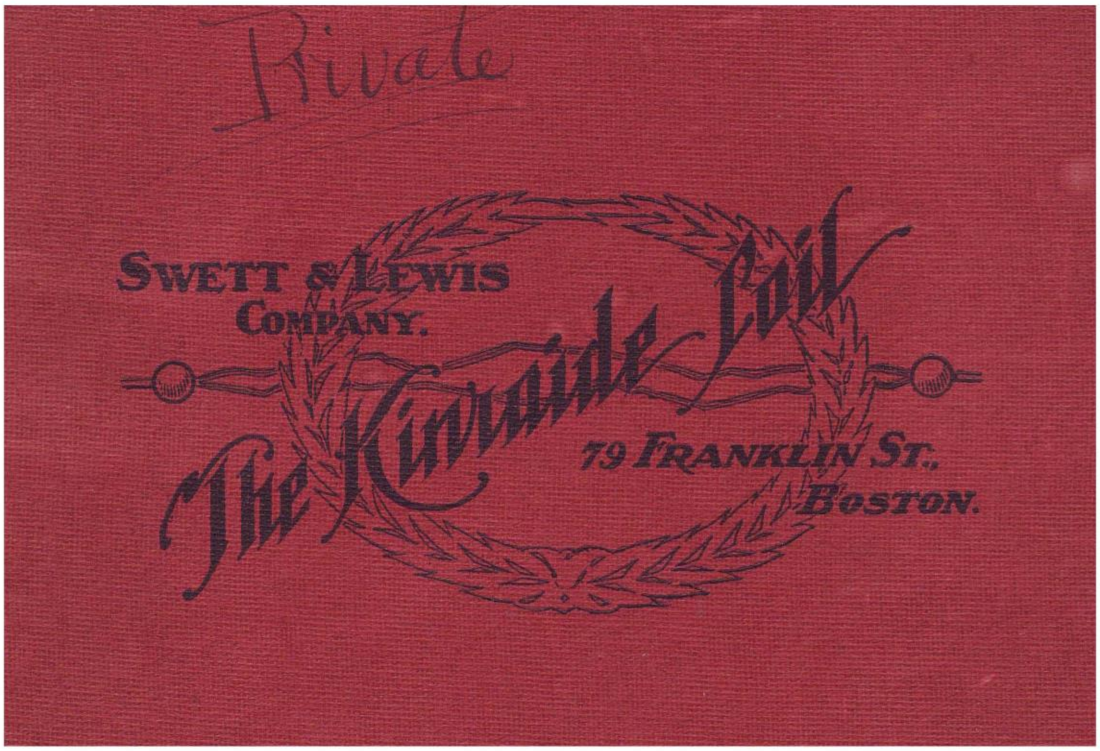


No. 36. **THE ENTITY OF ELECTRICITY.** (Enlarged)

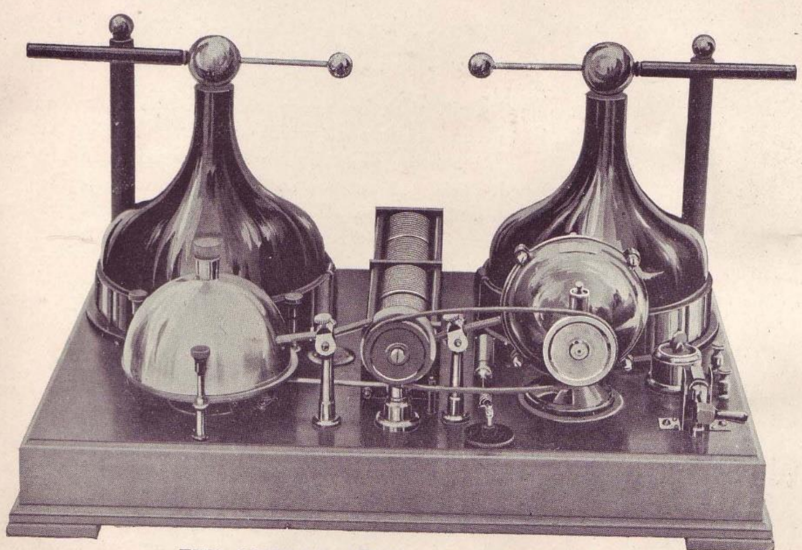
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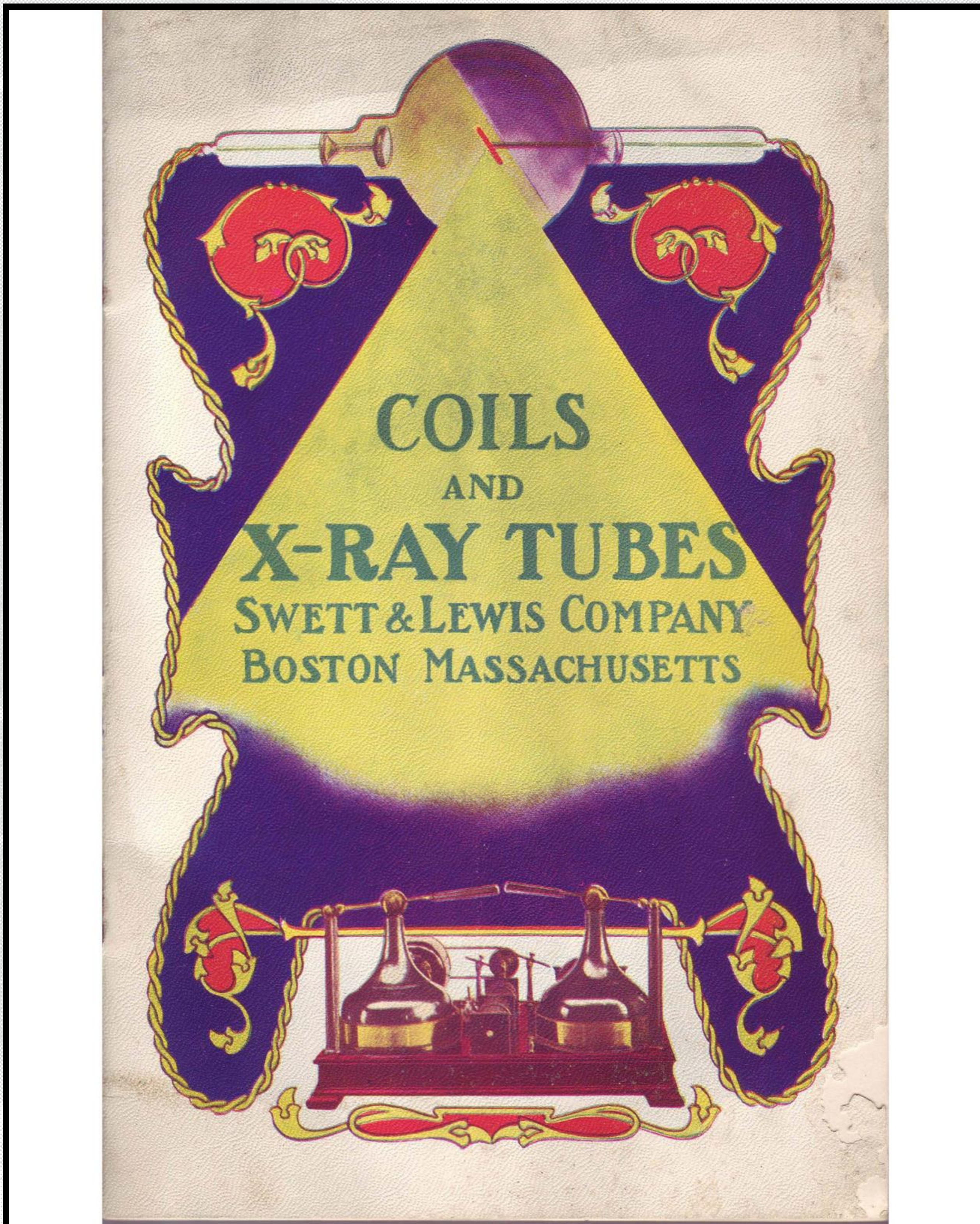
Condenser Series.

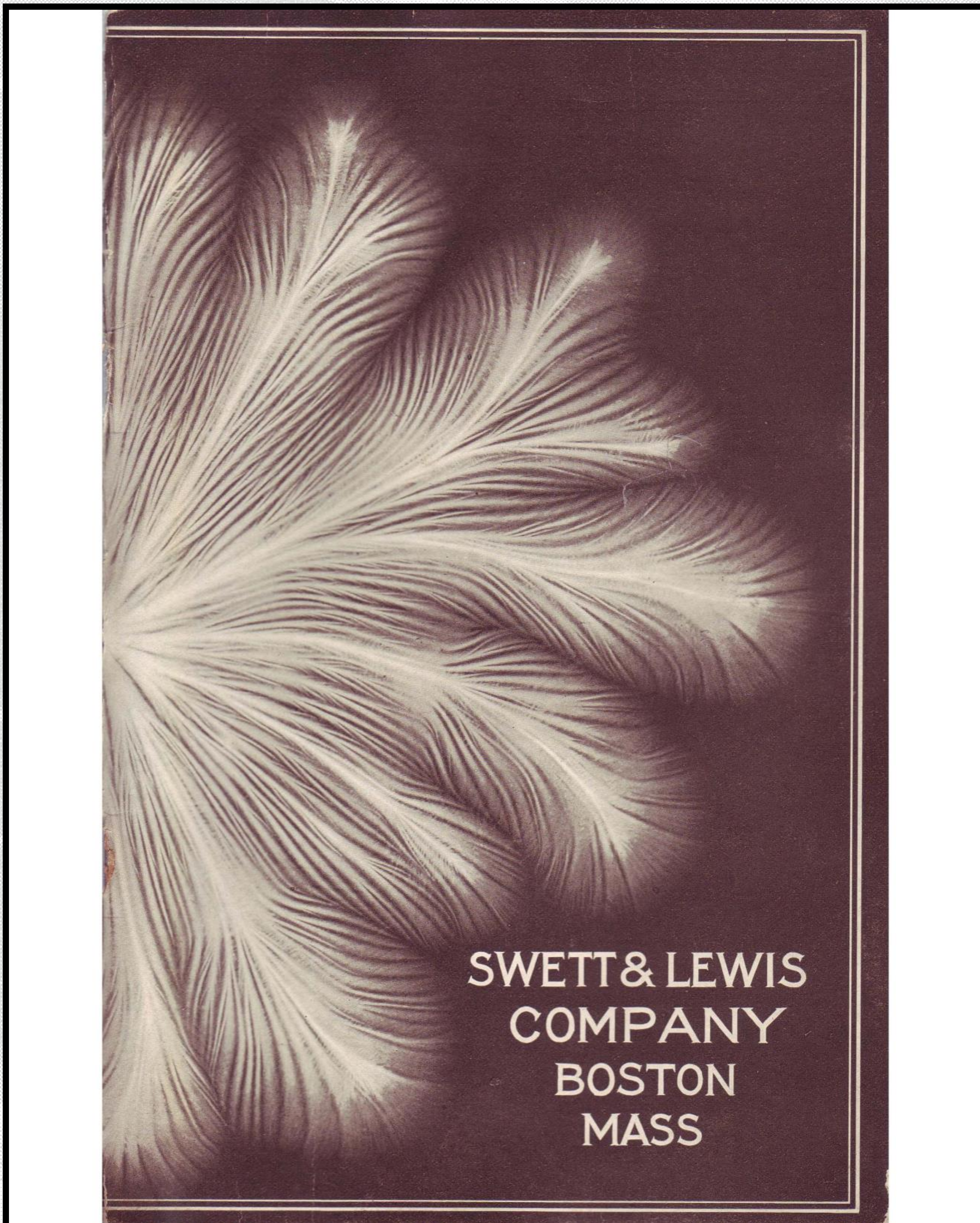

Private
SWETT & LEWIS COMPANY.
The Kinraide Coil
79 FRANKLIN ST., BOSTON.

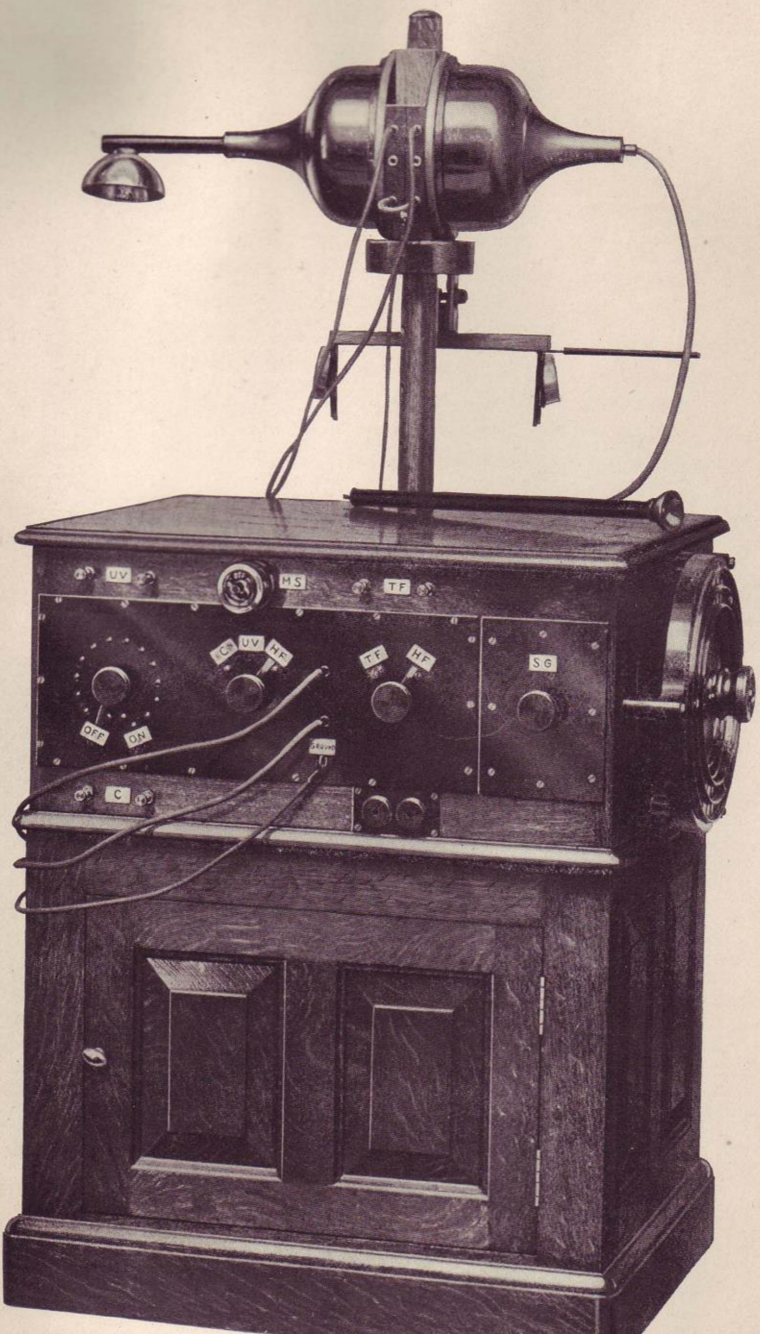
WE ARE PLEASED TO ANNOUNCE THAT WE ARE SOLE SELLING AGENTS FOR THE KINRAIDE COILS, WHICH HAVE NOT UNTIL NOW BEEN MADE ON AN EXTENDED SCALE, THE FEW BUILT IN THE LABORATORY OF THE INVENTOR, MR. THOMAS B. KINRAIDE OF JAMAICA PLAIN, MASSACHUSETTS, HAVING WON UNSTINTED PRAISE. MR. HOWARD JACKSON, THE WELL-KNOWN ELECTRICAL ENGINEER WHO HAS MANUFACTURED OUR GOODS FOR SEVERAL YEARS, HAS SECURED THE SOLE LICENSE TO MANUFACTURE UNDER MR. KINRAIDE'S PATENTS.



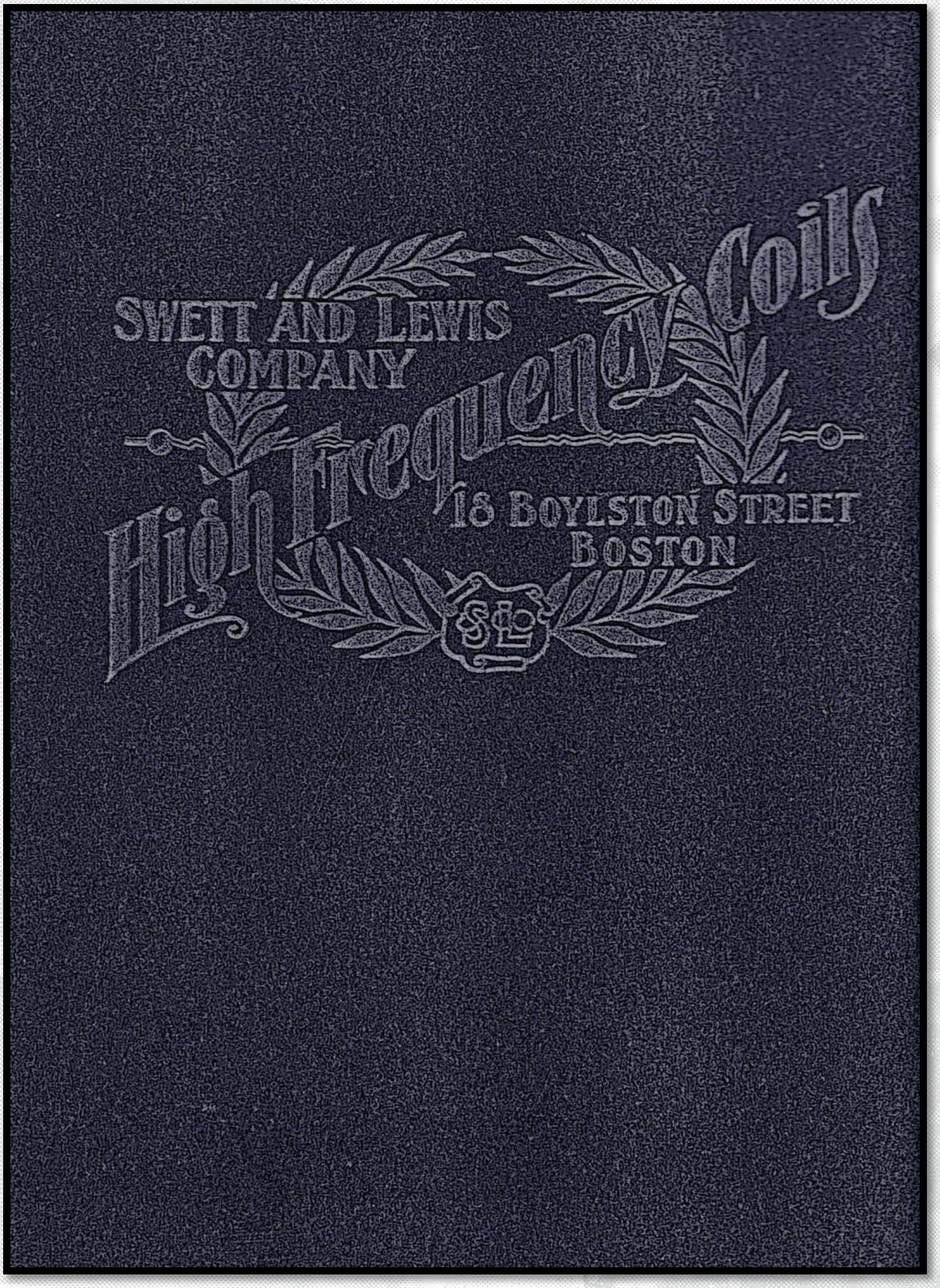
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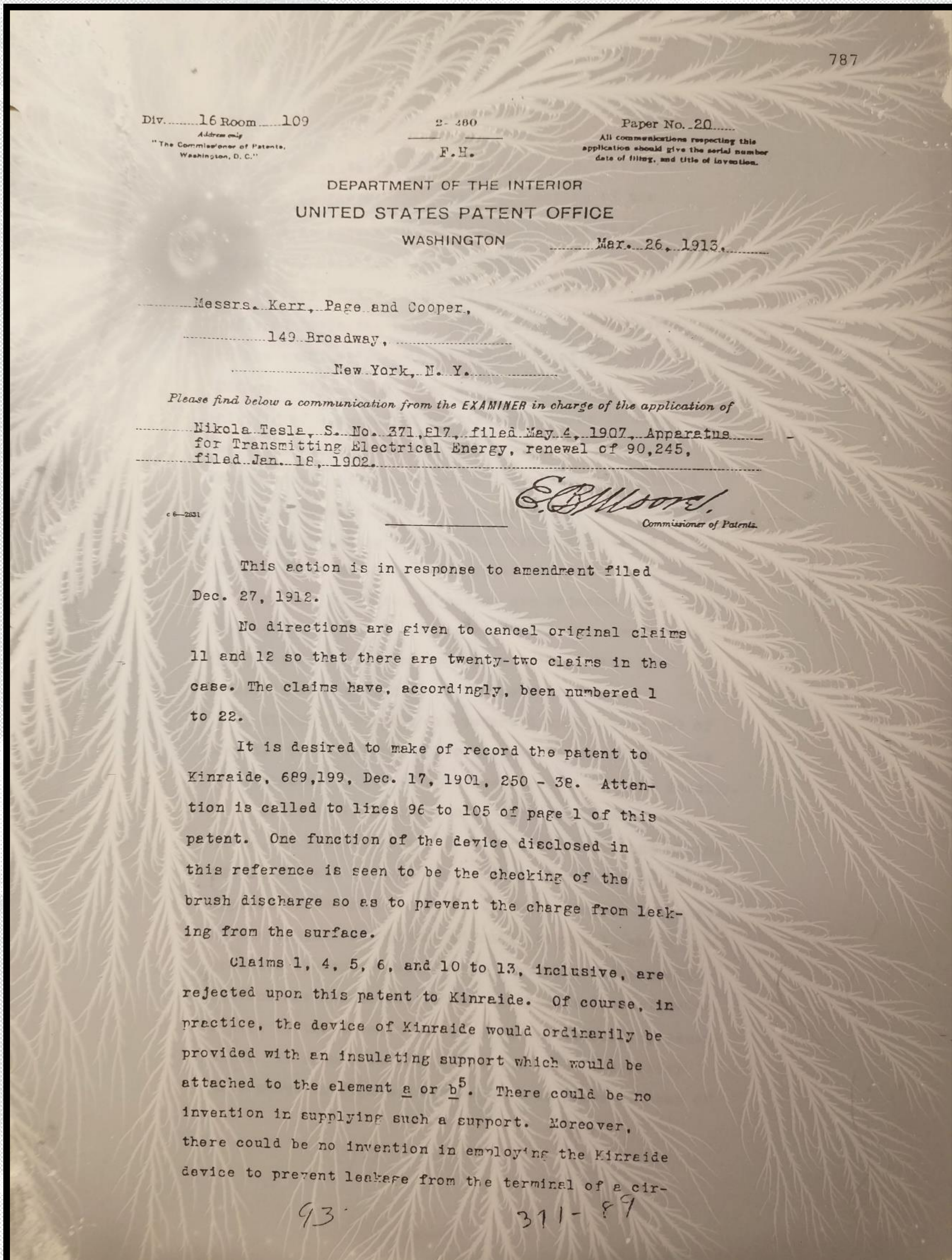
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2- 480

F.H.

Paper No. 20
All communications respecting this application should give the serial number date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR
UNITED STATES PATENT OFFICE
WASHINGTON Mar. 26, 1913.

Messrs. Kerr, Page and Cooper,
149 Broadway,
New York, N. Y.

Please find below a communication from the EXAMINER in charge of the application of

Nikola Tesla, S. No. 371,817, filed May 4, 1907, Apparatus for Transmitting Electrical Energy, renewal of 90,245, filed Jan. 18, 1902.

c 6—2831

E. B. Moore,
Commissioner of Patents.

This action is in response to amendment filed Dec. 27, 1912.

No directions are given to cancel original claims 11 and 12 so that there are twenty-two claims in the case. The claims have, accordingly, been numbered 1 to 22.

It is desired to make of record the patent to Kinraide, 689,199, Dec. 17, 1901, 250 - 38. Attention is called to lines 96 to 105 of page 1 of this patent. One function of the device disclosed in this reference is seen to be the checking of the brush discharge so as to prevent the charge from leaking from the surface.

Claims 1, 4, 5, 6, and 10 to 13, inclusive, are rejected upon this patent to Kinraide. Of course, in practice, the device of Kinraide would ordinarily be provided with an insulating support which would be attached to the element a or b^5. There could be no invention in supplying such a support. Moreover, there could be no invention in employing the Kinraide device to prevent leakage from the terminal of a cir-

93 371-89

Tesla was quick to dismiss the patent ability of Kinraide's work mentioned in Strong's letter, however the work was unique with regard to the patenting process. Likewise, later aspects of Tesla's Wardenclyffe patent were thrown out because of Kinraide having priority in designs - namely in the use of a toroid for an output terminal.

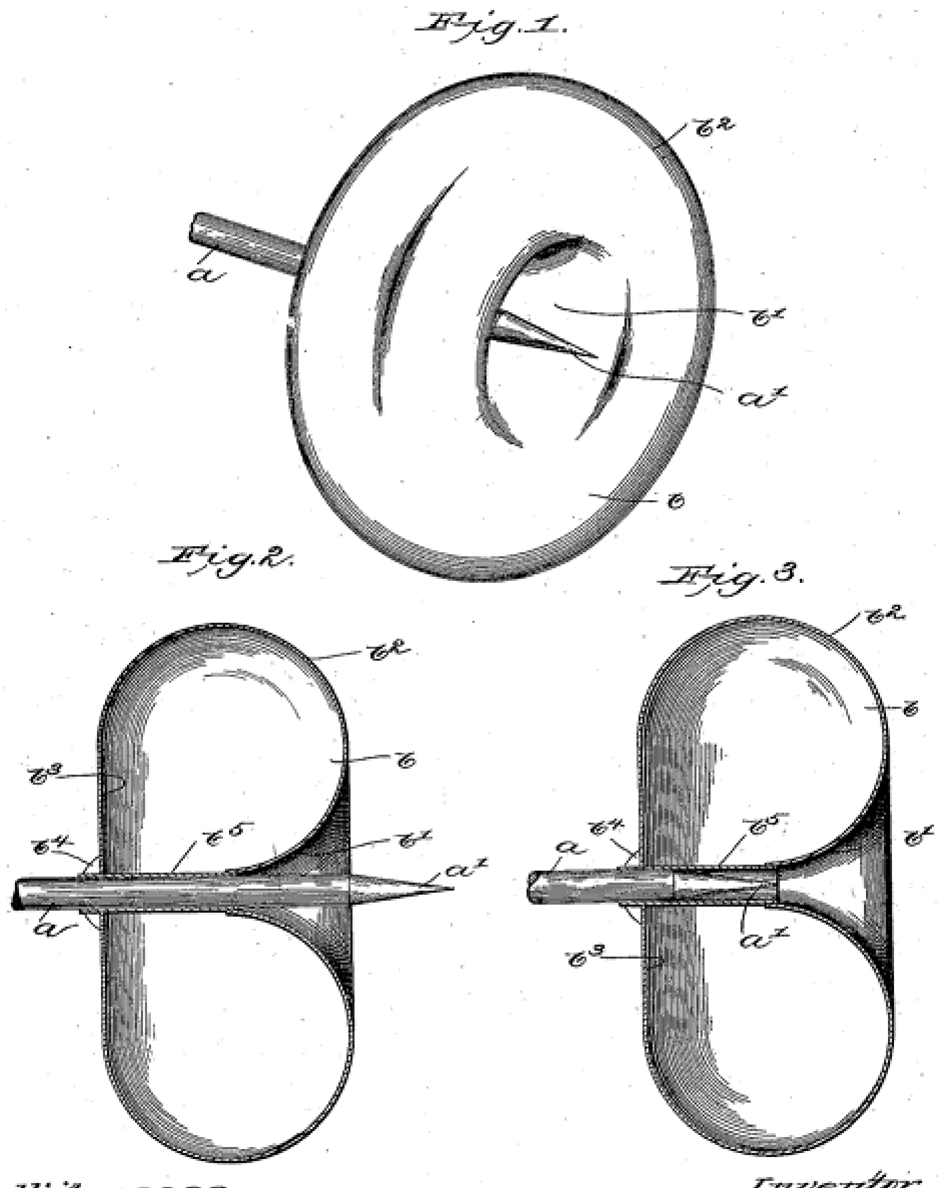
No. 689,199. Patented Dec. 17, 1901.

T. B. KINRAIDE.

ELECTRODE.

(Application filed May 2, 1901.)

(No Model.)



Witnesses.
W. C. Lunsford
A. B. Kaiser

Inventor:
Thomas B. Kinraide
by Bradley Gregory
Attys.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

Bulletin Thirty-Nine

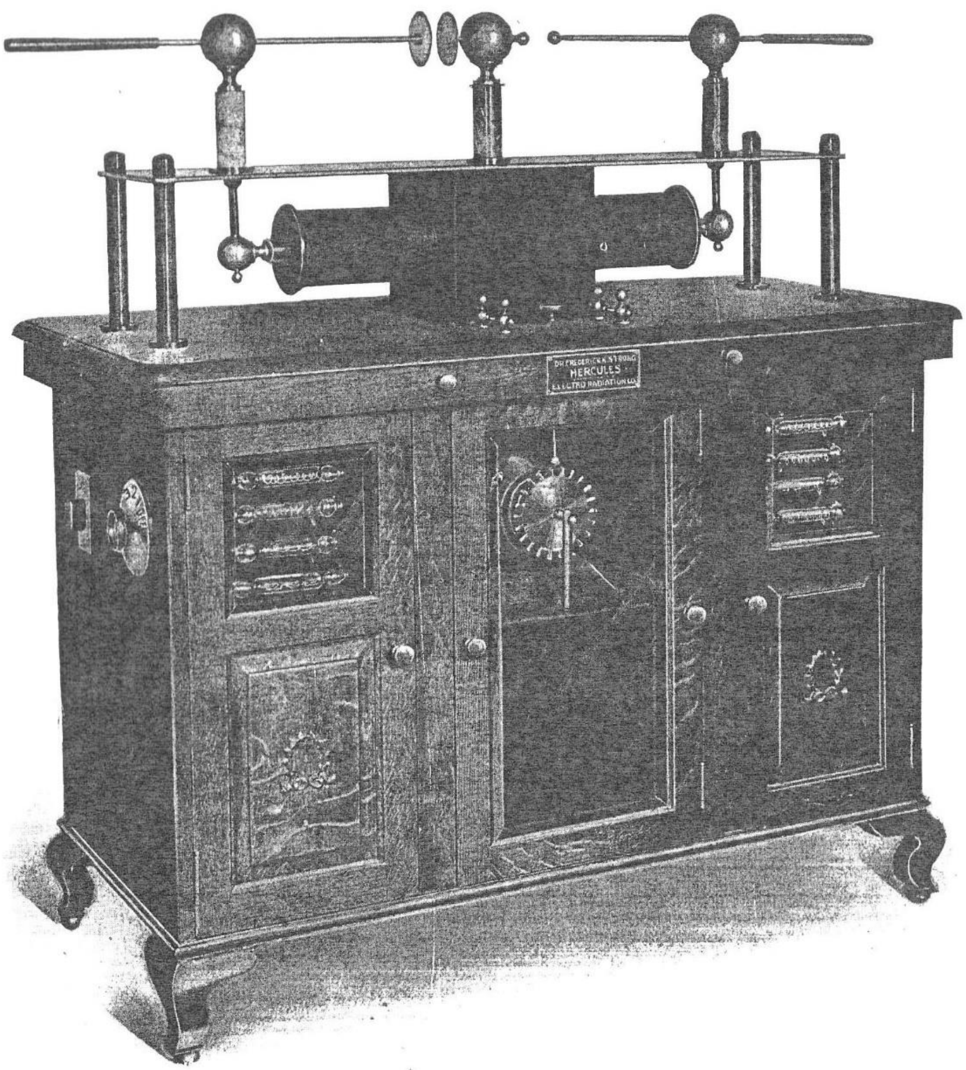
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FREDERICK F. STRONG, M. D.
SPECIALIST IN ELECTRO-THERAPEUTICS
BOSTON, MASS.

March 14, 1904.

Nikola Tesla,
Electrical Expert,
New York City.

Dear Sir: -

Some years ago when I was conducting a clinic in Boston Dispensary, devoted exclusively to the therapeutic use of the Tesla currents, I wrote you for information regarding certain technical details in connection with my work. You very kindly replied in a personal letter in which you fully explained the points about which I wrote you, and expressed your willingness to see me whenever I should be in New York.

I have been experimenting and applying high frequency currents for the past ten years, and have devised and perfected a number of instruments for their use in medical work. In this connection I have been invited to lecture before the New York Society of Physical Therapeutics, next Friday Evening, March 18. The manufacturers of my apparatus are sending me one for use, and I shall endeavor to demonstrate experimentally the phenomena of high frequency currents and the methods of applying them in the treatment of disease.

I have long desired to meet you personally, and to see some of your work, and if you feel disposed to receive me, and will enclose your address, and the time that would be most convenient for you, I will call upon you sometime on Friday, the 18th. If you cannot see me on Friday and could make convenient to do so on Saturday, I shall be delighted to stay over another day in order to avail myself of the opportunity that I have long desired and looked forward to with eager anticipation.

Trusting that you may feel inclined to grant my request, I am,

Very respectfully,
Frederick F. Strong

Dictated.

West Rindge, N. H., July 17, 1906.

Nicola Tesla,
Waldorf Astoria,
New York City.

Dear Sir: -

I am completing the manuscript for a treatise on the therapeutic uses of high frequency currents, to be published by the Rebman Company during the ensuing Autumn.

As pioneer and originator of this wonderful form of electrical force, I naturally appeal to you for assistance. I should be glad if you would send me the reference to your various publications on the subject, and if possible, any reprints which you may have at hand. The original suggestion of the possible importance of high frequency currents as a therapeutic agent, came, I believe, from you, yourself, although the literature on the subject accredits D'Arsonval as being the pioneer in high frequency therapeutics. I should be glad if you would refer me to some published statements in regard to the subject, which I can quote in my book to satisfy the claim which I have always made as to the priority of your work in this connection. I should also be pleased if you would send me one of your photographs, so that I can incorporate it in the book.

My work, for the past ten years, has been devoted to the application and study of the Tesla currents for therapeutic purposes, in contradistinction to those of D'Arsonval and Oudin which are used by European authorities. I believe that your currents possess a greater range of therapeutic value and are of far greater importance to the medical profession today, than any other form of high frequency currents or any other manifestation of electricity which is used. In order to thoroughly prove this point to the satisfaction of the profession, it is necessary to have your cooperation. Of course, due acknowledgment will be many for any assistance which you may give me.

Thanking you in advance, and trusting that I may be favored with an early reply, I remain,

Very cordially yours,
F. F. Strong, M. D.

F.F.S. / E.D.

July 23, 1906

Dr. F. F. Strong,
West Rindge, N. H.
My dear Dr. Strong: -

I note your request under date of July 18th, and would be glad to assist you in the matter as far as I can consistently. I will first call your attention to such publications as have been made by me in relation to high frequency. Unfortunately, I have no copies of these papers, but may be able to find one or two later and send them to you.

In the London Electrician of Sept. 12, 1890 is a letter in regard to a high frequency alternating machine which I had built, this being, as I believe, the first high frequency machine, and the first reference to high frequency work.

There are articles under the headings "Notes on Alternating Currents at Very High Frequency" Electrical Engineer (New York) March 11, 1891, Electrical World, Mar. 4, 1891.

As a reference to alternating currents of high frequency, Electrical Engineer of April 1st, 1891 and the London Electrical Review, April 17, 1891, also a reference to the same review, April 3, 1891.

There is a "Discussion on the Phenomena of Currents of High Frequency", Electrical Engineer, April 22, 1891. Experiments on the Electrical Discharge in Vacuum Tubes, Electrical Engineer, June 24, 1891, London Electrical Review, July 10, 1891.

Physiological Effects of Alt. Currents of High Frequency, Elec. World, Mar. 4, 1891; Elec. Engineer, Mar. 11, 1891; London Elec. Review, Mar. 21, 1891 and the London Electrician, Aug. 19, 1891.

Notes on Alt. Currents of Varying Frequency, London Electrician, Mar. 20, 1891.

Phenomena of Alternating Currents of Very High Frequency, Elec. World, April 4, 1891, also the Electrical World of April 25, 1891.

Induction by High Frequency Discharges, Elec. World, Feb. 20, 1892, Elec. Engineer, Feb 17. 1892, London Electrician, Mar. 4, 1892 London Elec. Review, Mar. 18, 1892.

Further Experiments with Condenser, Spark and Air Jet, Elec. World, Feb. 27, 1892, London Electrical Review, Mar. 25, 1892.

Dynamic Induction at High Potentials and Frequencies, Electrical World, April 2, 1892, Electrical Review, London, April 15, 1892.

High Frequency Electrical Induction, Paper read before Society of Arts, Boston, Technology Quarterly, Vol. 6, No. 1, 1893.

Curious Effects of Hertzian Waves, Elec. Engineer, July 4, 1894.

On Hertzian Waves in Laboratories and Electro-Plating Works, London Electrician, July 13, 1894.

Notes on the Effects of High Frequency Currents Passed Through the Body, Elec. Engineer, Oct. 10, 1894.

Dielectric Strength of oils in Alternating Potentials, Elec. Engineer, Feb. 12, 1896, Elec. World also, same date.

Electricity at High Pressures. Lecture before New York Electrical Society, Mar 29, 1899. Published in pamphlet form, and I think I can send you a copy of this pamphlet.

Apparatus for Obtaining High Frequencies and Pressures, Electrical World, Oct. 14, 1899, Electrician, Nov. 3, 1899.

It is of course, impossible, without comparison of dates of early experiments to settle the question of priority, no such comparison having been made, but you will find in the pamphlet on "Electricity at High Pressures" a reference to some experiments by Prof. Rowland of John Hopkins University which, indeed, involve the principle of high frequency induction from one set of turns to another insulated therefrom. Joseph Henry, many years ago, also induced by a leyden jar and condenser discharges, currents in adjacent circuits, and Henry pointed out first of all, the nature of the leyden jar discharge. I believe I was first to make a study of coils with air cores, that is, without any iron, for the production of high frequency induction, except in so far as the Henry experiments and the Rowland experiments referred to involve the same idea. I was, I believe, the first to employ an air jet on the condenser spark to increase the sharpness of the oscillations. Outside of these facts, and without any proper comparison of dates, it would be impossible to make any other statement.

Mr. Tesla, undoubtedly, was very early in the work, and may have been prior, but I think he was undoubtedly prior as to certain features of the work. It would be, I think, best, however, in a work such as you are preparing, to simply refer to the published papers and descriptions, which, in the absence of other data, must stand. I should in fact, dislike very much having to be put in the position of making any statement on the point, and would ask, therefore, that what I have said above regarded as for your own personal assistance, and not to be published. You will see that in the nature of things there is no criterion for an authoritative statement.

I will forward photograph, if I can, as soon as possible.

Yours very truly,
Elihu Thomson.

P.S. I am sending you a copy of the pamphlet on "Electricity at High Pressures".

A large number are rendering excellent service in editorial and publishing offices. THE ELECTRICAL ENGINEER has two, and will soon have more. Out in Milwaukee, two printing offices have made a specialty of setting up from phonographs, the compositors dispensing with time-honored "takes" of copy. Cleaner proofs are the result. Under such a régime Horace Greeleys cease to be a terror to the inoffensive "comp." A large number of lawyers, patent solicitors, stenographers, clergymen, authors, actors, musicians, linguists and other professional men are using the machines. An interesting and novel feature is the use of the machine for obtaining daily reports from foremen in large factories. Such men can generally talk vigorously and well, but a pen they shun and abhor. It has been discovered, however, that they will "pour out heart affluence in discursive talk" upon a waxen cylinder in a most admirable and effective manner; and this new method of factory reports is naturally coming into vogue with gratification to all parties concerned. Out of the whole 8,000 machines, it is estimated that 75 per cent. are in business service. New York has already 600 machines running.

The motive power to run the machines is a subject that is still actively discussed. This question can hardly be settled yet. The phonograph is driven by the ingenious little motor invented by Mr. Edison for the purpose; but that motor is energized in various ways. Sometimes the current is derived from an Edison-Lalande battery, one great advantage of which is its constancy. Sometimes the current is taken, through a resistance, from the incandescent lighting circuits. There is a very general preference for storage batteries, and nearly all the makes have been tried. With the graphophone have been coupled Lugo and other motors; and the small size Perret has been found very successful. In view of the fact that the 8,000 machines bid fair to become 800,000 in the next ten years, it will be seen that this question of motor and current for them is not one of the least interesting now before the electrical community. The customer of the sub-company pays $40 for his machine per year, or the small sum of 75 cents per week. The supplies are extras, of course, and there is a vast field for work and ingenuity in many of their details. By and by it may become a general practice for the companies to furnish the supplies to their patrons on a certain "flat rate" annual basis.

Amusement phonographs are still new, for, although countless exhibitions have been given, we have but barely entered on the nickel-in-the-slot period, when music and oratory, song and speech will be on tap. Nickel-in-the-slot phonographs have proved immensely popular wherever introduced, and there is not the slightest reason to believe that the favor they are in will be simply a short-lived craze. Every week brings forth its new singer, its new song, its new march or air; and the public has an ear that likes to be tickled. The phonograph as a Joe Miller jest book, telling the latest as well as the oldest good story, is an amusing companion. Incised with a yarn and a laugh from Eli Perkins, it is in more senses than one a "howling success."

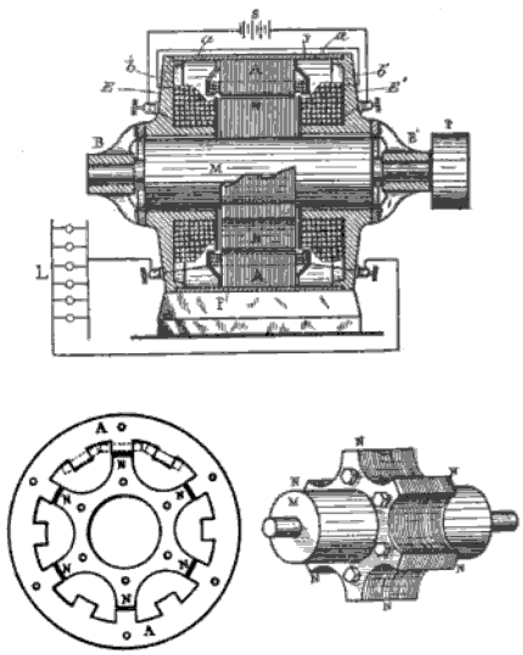
The past week, which has seen the issuance of this phonographic report has by strange coincidence seen, also, the issuance of an order from Washington for the treatment of phonograms as other ordinary mail matter. This is a step forward, and will lead to other improvements and developments, especially, it may be assumed, in the standardizing and unifying of apparatus, so that the same machine and the same record cylinder serve the same purpose everywhere.

THE ELGIN, ILL., ELECTRIC RAILWAY, which has recently been equipped with the Sprague system and was started up on the 4th of July, ran from the start without the slightest hitch, although no previous tests had been made of any of the power or electrical plant. The road was started with 2 cars, which they have already increased, and added another 50,000 watt generator. The cars were run free at the start till 12 o'clock, after which till 10 p. m. 4667 nickels were taken in fares.

PROF. THOMSON'S NEW ALTERNATING MACHINE.

WITH the high speeds now generally employed in alternating current machines the moving coils are more or less liable to derangement, so that they are subject to both mechanical as well as electrical strain. In order to overcome this difficulty and to obtain a compact as well as efficient machine, Prof. Elihu Thomson has recently constructed an alternator in which all the coils are stationary, and so that no moving contacts whatever are necessary to conduct the current from machine to line. The machine is shown in section in the accompanying illustration, Fig. 1, and consists of a stationary armature A, Fig. 2, within which revolves the field magnet, shown in Fig. 3.

The armature A is built up of a number of ring-shaped plates or sections of rings bolted together to form practically a compound laminated ring. It corresponds in a



FIGS. 1, 2 AND 3.—THOMSON'S NEW ALTERNATING MACHINE.

measure to a fixed laminated armature, and is supported in the interior of the outside casing.

The end plates E E' are joined at their outer portions by the iron frame-work or casing F, consisting of a cylinder surrounding the machine. It is designed to connect the outer edges of the end plates E E' magnetically with the stationary laminated ring A, surrounding the core M so as to embrace the centrally projecting portions of the core M. To the inner side of the structure A, and upon projections extending radially inward, are applied the coils, the ring and coils thus resembling a multipolar ring or cylindrical-shaped magnet whose poles are on the inside.

The field magnet coils are supported fixedly in the casing and energize the multipolar field magnet M, all the poles of which are of like name, as shown at N, N, etc. The core M is fixed to the shaft of the machine and has the laminated pole pieces keyed to it.

The ring structure A A has interior projections of double the number of the projecting poles N N N, carried by the ring core-piece. On these projections are firmly secured the coils in which currents are to be induced, and which are connected to the line wires. The field magnets, of

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course, require to be energized by a continuous current which can be furnished by a separate exciting machine.

The action of the machine is as follows: The moving field-poles N N N, etc., carried around on the revolution of the core-piece M, pass in front of the coils in which the currents are to be induced. The lines of magnetic force projecting from these pole-pieces cut across the wire on the coils transversely. The direction of the winding and the connection is such as to make the effects cumulative in the coils—that is, so that if a polar projection N passes, as in Fig. 2, over the centre of one coil to that of the next its lines are caused to cut the wire lying between those centres, half of which would belong to that coil, the centre of which is being left by the traveling pole, and half to the coil toward the centre of which the traveling pole is moving.

These actions of induction repeatedly following one another will be accomplished without a reversal of magnetism in the core-piece or even in the laminated ring structure supporting the coils in which the currents are induced; but, on the contrary, the lines of force will simply be carried rapidly past wire whose virtual direction of winding is opposite alternately, and this will generate impulses without the necessity of magnetic changes of polarity taking place in any of the core-pieces. Prof. Thomson is thus enabled to save a large portion of the loss due to magnetic changes or "hysteresis," in the iron of the machine, while still utilizing the iron to the best advantage in the construction of the magnetic masses subject to the magnetizing actions of the field-energizing coils. There is also secured a strong magnetic field by the expenditure of a minimum of energy in sustaining the same, besides which none of the wire of the machine need revolve, thus dispensing with rubbing-surfaces or sliding contacts when the machine is used for the generation of alternating currents.

ELECTRIC POWER AT GLOVERSVILLE, N. Y.

THE work now being done by electric motors at Gloversville, N. Y., the largest glove manufacturing town in the United States, is of more than ordinary interest, and presents one or two novel features. The Gloversville Electric Company started their plant on December 1, 1889, and began to supply electric power just a month later. They are now operating 26 motors ranging from ½ to 2 h. p., and these 26 machines represent so many different glove factories. The ½ h. p. motors run eight sewing machines each; the 1 h. p. from 12 to 14 machines; and the 2 h. p. from 18 to 22 machines. The prices for current are $90 per year for 1 h. p. and $35 for the use of the motor; $50 for ½ h. p., and $25 for use of motor; $175 for 2 h. p. and $50 for use of motor. The motors are owned and supplied by the company. The users have become familiar with their care, and they give very little trouble to the company in the care of them; but they are of course kept under surveillance and a weekly inspection.

The service is furnished from 7 A. M. to 6 P. M., each day, with an intermission at noon, and proves very satisfactory to its patrons. The power is supplied by Thomson-Houston arc machines generating a current of 6.8 amperes. These machines are used at the end of the day for lighting the town with arc lamps. The motors used are the constant current made by the Excelsior Electric Co., of this city, and have been found eminently suitable for their work. The Gloversville company now have applications for power as high as 40 h. p., and they are considering the advisability of putting in large generators to deliver a 500 volt current to furnish power for that special work. The company are obtaining their prime power from compound condensing engines, that answer admirably and are preferred to the ordinary non-condensing high speed type.

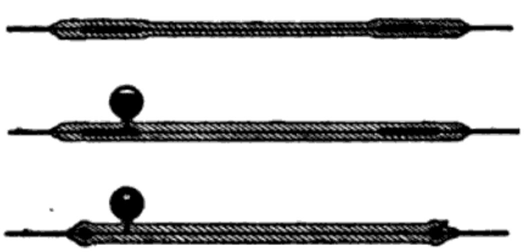
The company have begun to furnish motors as small as ¼ h. p., running the service right into the houses of the operators, so that as the work is paid for by the piece, they can take it home and do it outside the factories. This is a little point, but it has its significance.

The factories really make money by the motors they put in, as they charge the "help" that use the machines 50 cents per week for the use of the motor, the work being done by the piece, as stated above. At first no little objection was made to this, but now the operators are glad to pay the charge, for the reason that they are enabled to do very much more work with the machine run by the motor than in the old way. There is thus a saving and a higher profit in the work for everybody concerned.

FIELD'S MERCURY THERMAL CUT-OUT.

The protection of telegraph and telephone apparatus from abnormal currents has led to the construction of a large number of cut-outs, both electro-magnet and thermal in their nature. In order to avoid the introduction of an electro-magnetic device which might introduce retardation, and on the other hand to overcome the objection to lack of uniformity and fragility in fine fuse wires, Mr. Stephen D. Field has recently invented an ingenious cut-out in which mercury is employed as the fusible, or rather volatile, material. Another object aimed at is to obtain such a construction that upon the cessation of the abnormal current the circuit to the instrument is automatically restored without the replacement of any material in the cut-out.

The simplest form of Mr. Field's cut-out is illustrated in the accompanying engraving, Fig. 1. It consists merely



FIGS. 1, 2 AND 3.—FIELD'S MERCURY CUT-OUT.

of a glass tube with a fine bore which is filled with mercury and has two conducting wires sealed in at the ends. The passage of an abnormal current heats the mercury, vaporizes it and the pressure generated bursts the tube, thus rupturing the circuit.

In order to provide for the automatic closing of the circuit above referred to, the construction shown in Fig. 2 is employed. Here a chamber is placed at one end of the tube, which is part filled with the mercury. The air, which occupies a portion of the chamber, being an elastic medium, allows the expansion due to the vaporization of the mercury in the capillary portion to take place without rupturing the structure, as the air becomes compressed and the separation of the column of mercury in the capillarly tube can take place, thus opening the circuit in a reliable manner without destroying the apparatus.

Another form of cut-out, shown in Fig. 3, is similar to that shown in Fig. 2, except that instead of leaving a open air-space in the chamber, a rubber ball filled with air is placed in it and the chamber completely filled with mercury This prevents the escape of the air from the chamber into the capillary tube in transporting or handling the appaatus, while affording a sufficiently elastic medium to preserve the apparatus from destruction by the vapor-pressure gnerated in its operation.

Among the practical advantages claimed by Mr. Field for this form of cut-out, are first, that, if using only pure distilled mercury, it is possible to have absolute uniformity in the conductivity of a given size of cut-out. Again, the

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NOTES ON ALTERNATING CURRENTS OF VERY HIGH FREQUENCY.

BY

Elihu Thomson

The interesting account of the novel experiments given by Mr. Nikola Tesla in the *Electrical World* of Feb. 21, 1891, and relating to the phenomena of alternating currents of very high frequency, lead me to make a statement of some of my own obervations while working in similar directions. The highest number of alternations which I have had at my disposal up to the present have been 8,000 to the second, a rate somewhat below that which Mr. Tesla has obtained, but which, nevertheless, shows properties and brings about actions and results similar to those which he described. The physiological actions of these rapidly alternating currents have been very ably investigated by Dr. Edward Tatum, some of the results of whose work I have presented in a separate communication.

Mr. Tesla's experiences in relation to the static effects of these currents of high frequency are similar to those noted by myself, particularly the small surface of the condenser which is able to transfer, or permit to be transferred, a considerable amount of energy through a dielectric, owing to the exceedingly high rate at which the changes of direction of charge are made.

The following experiment which was tried by me some months ago, is interesting in this connection. An incandescent lamp bulb was constructed, in which only a single platinum leading-in wire was used, on the end of which, inside the bulb, was mounted a single slip of carbon, two or three inches in length, it being one leg of a broken incandescent lamp filament. Two-thirds of the lamp bulb was now immersed in an outer vessel of water, leaving the single wire above the water for attachment to the source of alternating currents at one terminal, and the other terminal was connected with the outside water, which was rendered slightly conducting by salt dissolved therein. The water surrounding the lamp bulb formed, of course, an outer condenser coating, while the vacuous space and straight slip of carbon were the means for the conveyance of a charge to and from the inside surface of the bulb, which was, of course, exhausted to the ordinary vacuous condition, as found in an incandescent lamp. When an alternating potential of about 1,000 volts, and with a rate of alternations up to 5,000 per second, was applied to the carbon strip, the filament was brought to bright incandescence simply by the bombarding action of the residual gas, as in the Crookes tubes, while, of course, no complete circuit existed, the condenser action of the lamp bulb allowing sufficient current to flow. At the same time the glass of the lamp bulb not immersed in the water, became rapidly heated, indicating that that portion which was immersed in the water would have become equally heated had it not been subjected to the cooling action of the water itself.

The retention of the arc, as with direct currents, and the high note evolved by it, have been noted from the beginning of my experiments with these high period currents. Mr. Tesla expresses surprise that he was enabled to hear the note from an arc in which the alternations of current were more than 10,000 per second. Mr. Tesla will pardon me for calling his attention to the the fact that he is taking as the limit of audition in this case sounds from 5,000 to 10,000 complete waves per second, which is far below the limit at which sounds become inaudible to ordinary ears, cases existing in which a pitch corresponding to over 30,000 per second has been heard, according to some authorities.

The cause of the persistence of the arc with very high period alternations as stated by Mr. Tesla is undoubtedly the correct one, *i. e.*, that the gas stream has no time to cool between the alternations, and its variations of temperature must therefore be quite slight. The conductivity of the vapor or gas stream constituting the arc therefore remains nearly constant when the rapidity of alternations is sufficiently great.

The characteristics, stated by Mr. Tesla, as requisite to be possessed by machines suitable for obtaining constant current for the working of arc lights, are of course connected with the fact that in such machines the characteristic curve indicates a drop or fall in the electromotive force developed on a slight excess of current above the normal and, on a decrease of current, a raising of the electromotive force to a point above the normal.

It is not, however, in accordance with my experience, that the undulation of the current is almost essential to the success of an arc light system, nor do I think that properly constructed clutch lamps depend for their success any more than do finely constructed clockwork lamps, on the presence of a rapidly varying current due to a small number of armature coils and correspondingly small number of segments in the commutator. In fact, I have run with perfect success clutch lamps in circuit with coils of such large self-induction that any but very slight fluctuations were wiped out, and without introducing any particular difference in the behavior of the lamps. It probably is true, however, that slight gentle fluctuations occurring at very moderate intervals may be of benefit in the working of clutch lamps by keeping, as it were, the clutch mechanism in a state of vibration or tendency to open or close, but it can scarcely be doubted that if this benefit exists for such lamps a similar benefit would exist on the operation of clockwork lamps, as a similar fluctuation would give rise to a continual tendency in such lamps to keep the detent or escapement free enough for delicately letting-go teeth for the feed ; but the fact that large numbers of lamps are in use in which the feeding of the carbon, either by clutch or by clockwork, is under the control of a derived circuit magnet only, and that such lamps operate with the greatest satisfaction, shows that the undulations mentioned by Mr. Tesla are not necessarily a factor to be considered. In such cases the self-induction of the arc branch is negligible as compared with that of the derived circuit magnet controlling mechanism, and the fluctuations therefore would pass through the arc without affecting the said magnet to a perceptible degree, particularly as the potential around the normal arc with slightly different current strengths flowing is nearly constant.

I may add that the experiments of Mr. Tesla in relation to the action of the condenser and the elevation of potential brought about by it are decidedly interesting and point to the possibility of obtaining a pure resonance effect. This would require, however, that the periodicity of the alternations be preserved very rigidly during the experiments, and involves the production of an unvarying or perfectly constant speed in driving the generating machine, a condition not easily obtained in practice.

In making the above notes on the highly interesting and valuable account given by Mr. Tesla, I desire to state that in whatever way my notes may appear as criticism of Mr. Tesla's views, they are not made in any unfriendly spirit, but with the desire of reaching the exact facts which it is the object of scientific investigation and discussion to ascertain.

SITES FOR CENTRAL STATIONS.

According to the *Elektrotechnische Zeitschrift*, the simplest method of determining the best site for a central station will be to find the centre of gravity of the system, taking the values of various points in the area as proportionate to the density of current to be supplied at these points, in which case the total weight of copper in the feeders will be at the minimum. This calculation will, however, have to be modified when the considerations of cost of site and rent and, it may be, cost of cartage of fuel and so forth, are taken into account.

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Letters to the Editor.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted, will oblige by mentioning the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER *150 Broadway, New York city.*

DISCUSSION OF THE PHENOMENA OF CURRENTS OF HIGH FREQUENCY.

It is not from any desire to have the last word that I have answered Mr. Tesla's statements as they appeared; it has simply been to correct misunderstandings. In regard to the experiment which I mention, as performed by immersing in water a lamp bulb in which a single strip of carbon had been mounted and connecting the water and the filament to a source of high potential alternating current at high frequency, and whereby the strip of carbon was brought to bright incandescence, I simply said that conduction through the glass could not have had any effect in this experiment. I made no general denial that a slight conduction occurred with even the best dielectrics. The glass in my experiment being immersed in water, the assumption of high temperature which Mr. Tesla makes as increasing the conductivity of the glass, is not to be considered in this case. The glass was only heating where it was not so immersed, and where, therefore, no connection with the circuit existed.

Mr. Tesla bases a long statement about dielectrics, insulation, resistance, perfect conductors, degrees of conductivity, etc., on the statement I made in relation to the experiment and the phenomenon it presented; and he even asks whether I have "then never measured insulation resistance" and "by a conduction current." Similar irrelevant questions follow this typical one. I have said that "if conduction through the glass were a possibility (in the experiment and accounted for the phenomenon presented) this action (of charging a lamp bulb as a Leyden jar and receiving a charge therefrom,) could not occur." Mr. Tesla does me the injustice of applying a statement which related to a particular experiment and phenomenon to classes and conditions of phenomena which any one at all familiar with the circumstances would rule out. Mr. Tesla says: "My statement that conduction is concerned to some, *though perhaps negligible*, extent in the experiment above described was, however, made not only on account of the fact that all bodies conduct more or less, but principally on account of the *heating of the glass* during the experiment." The italics are mine. In the experiment the glass was immersed in cold water, and only that portion not immersed and not in contact with the current conductor or the surrounding water, was warmed. This disposes of the paragraph of contentions of Mr. Tesla based on heated glass in the experiment.

In regard to the estimate of the number of complete waves of sound corresponding to a given number of alternations, I freely confess that I was in error, and that the number given by Mr. Tesla is correct. The number of complete sound waves does, as Mr. Tesla points out, correspond to the number of alternations, as the expansion and the contraction of the arc stream, corresponding to wave condensation and rarefaction, occurs with each alternation. This is a point which I had missed in the former consideration of the matter, but, of course, if the limit of audition is above any of the rates considered, it would not affect the argument except as it relates to the degree of approximation to that limit.

Without calling upon Mr. Tesla to state how far "Earth is from Heaven" in his view, I will simply state that my experiment of five or six years ago, which called forth his remark, certainly did teach me something then, and added somewhat to my information in certain directions.

I was perfectly well aware of the effects of self-induction, including impedance, pointed out by Mr. Tesla, when I spoke of the insertion of a coil of large self-induction into a circuit of arc lights, as steadying the current and lessening its undulations. In regard to the effects of self-induction I may state, that the property of impedance I have always regarded as one of those effects.

It is not true, as stated by Mr. Tesla, that self-induction "renders the undulations more pronounced." Whether it will do so or not depends on the shape of the wave of undulation. Not all shapes of wave have the greatest rate of change when the current has a small value. What is true in this respect of a sine curve would not be true of a saw-tooth wave. But the point under discussion originally was the effect of a large self-induction interposed in a circuit of arc lights in which the current was of a fluctuating character. The current may be considered in this case as made up of a steady current of an average current value, upon which has been superimposed an alternating current of small value, or it may be considered as made up of a steady current of less than the average value with a pulsating current of small value superimposed. These assumptions, to be exact, of course, are made on the basis that in the fluctuations the strength of the current does not change very greatly, or that the minimum current and the maximum current values are not far removed from the average value. Now the effect of self-induction introduced into such a circuit with arc lights is, by its impedance, to diminish the value of that portion of the current which is, so to speak, alternating or fluctuating; and whether the waves of alternating or pulsating currents, so greatly diminished in amplitude, will be sharpened or smoothed out by self-induction will depend upon their original form. It is the effect of self-induction in producing impedance, and therefore restricting the value of the fluctuating or alternating current strength, superimposed on the much larger constant or steady current, to which I referred in speaking of the smoothing action. Mr. Tesla was right in his general statements of principle, but wrong in his application of them to the case in point. He was not right, however, in separating the effect of impedance from self-induction in the case under discussion.

I have no desire to prolong this discussion and will leave out of consideration any reference to effects on clutch or clockwork lamps, or to the physiological effects of currents. I have in the above comments confined myself strictly to those matters which it seemed necessary to have cleared up in some way. I hope that in stating my position in relation to the matter I have made myself clear so as to avoid further misunderstandings.

ELIHU THOMSON.

LYNN, MASS.

IMMERSING CONVERTERS IN OIL.

I have read a recent article by C. E. L. Brown on the "Uses of Oil in Insulators and Transformers." Mr. Brown states: "The application of oil as insulating material for transformers carrying a very high potential was first proposed by me," meaning Mr. Brown himself. In your journal of April 15th, Prof. Elihu Thompson writes: "It may be interesting to your readers to learn that the use of oil in converters, was the subject of a patent applied for by me on May 9th, 1887, or about four years ago, the number of the U. S. Patent being No. 428,648."

I received a patent dated Oct. 25, 1878, No. 210,987, in which the following claim was allowed: "The within-described method of insulating induction coils or bobbins of wire of electrical instruments, that is to say, by immersing said bobbins or coils in a liquid insulating substance, as set forth."

Professor Thomson's patent is titled "A casing for induction coils," and although in his specifications he speaks of the value of oil, in his claims he steers very clear of that one claim of mine. He has six claims all commencing with the words "A combination" of different things, but having little or no reference to the fundamental principle of oil being used in induction coils or converters or transformers. He doesn't make use of the words "converters" or "transformers."

DAVID BROOKS.

PHILADELPHIA, PA., April 17, 1891.

ELECTRICAL ENTERPRISE IN MANITOBA.

Mr. W. Bathgate, of the Manitoba Gas and Electric Light Company, recently invited the members of the city council to the works of the company in Winnipeg.

The boiler house is 70 feet long by 40 feet wide. There are nine steel boilers of 740 h. p. One hundred pounds of steam is carried. The smokestack is 100 feet high, and five feet in diameter. The engine and dynamo house is 80 feet square and contains two pairs of compound surface condensing Brown automatic engines of 200 and 400 h. p. respectively. The driving wheel of the 400 h. p engine weighs 16½ tons, and is 18 feet in diameter and 40 inches face, and drives the largest belt that has been made in Canada—three ply, 3 feet 4 inches wide and 88 feet long. The shafting with which it is connected is fitted up with friction clutch pulleys made by the Vulcan Iron Company, from which are run two Thomson-Houston arc machines for city lighting and one 1,000-light incandescent dynamo, with space for two more large incandescent dynamos. Three incandescent dynamos of 2,000 light capacity are run from the shafting, driven by the 200 h. p. engine as well as the arc dynamos which are used for private lighting. The total capacity of arc plant is 125 lights, 2,000 c. p.; the total capacity of incandescent plant is 3,000 lights, 16 c. p., with capacity for two more incandescent machines of 2,500 lights, to be installed this fall. The pumps in connection with each engine consist of one Blake air pump, one circulating pump, one duplex boiler feed pump, and one large Northey auxiliary pump fitted up with 100 feet of 2-inch hose for fire protection purposes—all driven by steam. The workshop contains a 7 h. p. Otto gas engine furnishing power for blacksmith and machinery shops, which are fitted with two lathes, one 15 foot and one 14 foot bed, screw cutting machines, emery wheel, grindstone, drills and punching machines, all the necessary repairs for both gas and electricity, being done in these shops.

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FREDERICK FINCH STRONG, M. D.
6129 FOUNTAIN AVENUE
HOLLYWOOD, CALIF.

Nov 21;1951

Dear Mr Strickfaden-

I tried in vain to get you on the phone but no one answered. Hope you are still well and everything is going finely with you.

I am now in my eightieth year and still taking patients. our rent has been raised and we will be compelled to move if we can find a cheaper place. I shall hate it as we have been here for thirteen years and it had grown to seem like home. My five meter ultra short wave(which I call my "VITAL N RMALIZER) Do you know anyone with High Blood-pressure.Thirty two years ago I was running a systolic of over Two hundred. The Met. Life Co rates High Blood pressure as PUBLIC ENEMY NO1 it kills 600,000 annually (more than Cancer and tuberculosis combined I am now running a norm l pressure of about 155 and am feeling very well dispite my age. Are you still doing ELECTRICKS? I have all my tesla apparatus and dont know what to do with it. Do you know anyone who would take it off my hands. We are sadly in need of money and I would sell all my H-F apparatus for fifty dollars. You have no doubt seen the million volt coil which I gave to the Planetarium. Can you not come up and look over my High-frequency "JUNK-PILE". Today Jose Iturbe came in and played for us. He is going to try to sell my piano forme He says "IT IS A VERY GOOD PIANO" I also want to sell my harp We shallbe very glad to see you again. If this reaches you please call me up

your old High-frequency friend

Frederick F. Strong

Letter from Frederick Finch Strong to Kenneth Strickfaden, from Harry Goldman Collection



Kenneth Strickfaden, signed photo from Frank Jones Collection

October 15, 1954

Tesla was “Nick” to us, for my late father had the pleasant duty to write the checks for his millionaire supporters who owned Okonite Wire and Cable and who waxed rich on the lush profits of selling the telephone rights for Manhattan Island to the NY Telephone Co. for some $17,000,000. This was a tax-free transaction and that sum was quite a sizable one in those days. They loaned money to Marconi through their British group and financed in part Fessenden, de Forest, and many other lesser-knowns in the world of science. Tesla was their “problem inventor.”

They were not alone in their difficulties with him for J.P. Morgan, the elder, always had Nick as his pet problem. I worked for Morgan briefly on his palatial steam yacht, Corsair, as installation engineer and for Senator Nelson W. Aldrich on whose prize steam yacht, Alvina, I sailed as test engineer around the world. Both men had influence. Even John Hays Hammond, Sr., who loaned Tesla the cash for his robot was unable to understand this strange genius.

Edison had tried in his hale and bluff manner to befriend Tesla but his remarks had been construed by the extremely sensitive Tesla as an insult. With his typical Europeon-Slavic ideas of gentlemanly deportment, he was a strange figure in the rough-and-tumble field of pioneer wireless and electricity. Most of the scientists that he met were good fellows. Some were of the back-slapping variety such as Edison, Fessenden, Marconi, de Forest, Fleming, Preece, Lodge, Slaby, Zenneck, and Seelig. The old New York Yacht Club group headed by Morgan, Gates, Rockefeller, Lieter, Davison, Carpenter, Bennett, and many others that my father knew so well, were all of the same order with perhaps a bit more restraint in being companionable.

I knew these men and answered to their good-natured nickname of “John the Wireless Man,” a title that tickled me no end as I liked to make sparks and create spectacular displays of high frequency. Nick, the quiet, studious, very proper, waist-bowing Germanic (Slavic) mannered Europeon, never seemed to quite fit into the cruder American scene. He seemed like a man apart - an individual of considerable reserve. This, coupled with his strange phobia of failing to shake one's hand and to dine with peculiar manners of hygiene made Nick a marked man. Many considered him a plain snob. Others called him a “Nut” while others referred to him as “The Genius” and were always making excuses for his actions taking pains to explain that this was to be expected of a genius.

Those who worked for Nick were rarely taken into his confidence. His sketches were always in parts. His records were never complete. He feared pirating. He was pirated and it was a shame that the man who refused the Nobel Prize on the grounds that he was a discoverer of principles rather than an inventor should have been so pirated, lied about, and discredited by his contemporaries. They lifted his ideas and went merrily on as though Tesla's inventions were free property.

I paled around with men like Earl Ovington on whose Blerliot monoplane I installed my original system using the first counterpoise antenna in 1910. While Earl soared at some 1500 feet over Mineola-Hempstead, we carried on the first two-way radio from plane to ground. He became one of the first air mail pilots. Ovington was a millionaire's son and a close friend of Tesla.

Earl would put on spectacular displays of fireworks using a huge Tesla coil mounted on a platform over the Crows at the old Madison Square Garden. He would let me venture forth on the glass platform and take big sparks of terrifying length off a wand that I held in my hand. I soon found that we had a daily matinee and evening demonstration for the duration of the electrical show which attracted vast crowds who expected to see us both electrocuted. Earl was a show-off and he loved it. I was a scared kid even though fascinated with the sparks that I loved. Tesla would stand by with a paternal eye on us both. Tesla put on parties at his lab for millionaire friends. Nick loved to get the lights low and put on eerie displays. I must confess that I tried to emulate him many times and it was fun.

My first wireless transmitter of any size was a 10 KW open-core transformer and to that I had an open gap and a huge glass plate condenser in oil. With my huge antennas over Yonkers, I could get the distance that made the boys envious as I worked the ships in the mid-Atlantic. Prior to 1912, no license was required. The air was free and we pioneers did have the fun that no one these days will ever understand or imagine.

Nick grew very peculiar with age. Louis Pacant, my old chum, used to visit Tesla. Louis had been a smart boy in that he signed up over nine-hundred theaters on sound across the U.S. When Western Electric found they had been beaten, they paid-off handsomely to Louis. He enjoyed that for, as a poor N.Y. boy who had worked his way through Pratt in Brooklyn, he got a kick out of rubbing elbows with the “big boys.” As a quiet-mannered and discreet consulting engineer, he soon found Nick to be a companion of sorts. They would chat at Nick's penthouse but Louis could get so far. Nick had the peculiar reserve and suspicion that made him a unique figure. There were no others as close as Louis.

I could ramble on here with much. I have completed a documentary on the history of radio and am working on another on Howard Armstrong, my old schoolmate, whom I helped with his first feedback ideas and assisted with his first patent in Yonkers after his father refused to support him.

I wish that you would get some sort of eastern Tesla club among the science teachers with the idea of letting the younger generation know some of the Tesla thrills of discovery. I would like to see the Tesla Society give a medal each year for some worthy scientific achievement.

Unfortunately, words are totally inadequate to express the thrill of youth when engaged in pursuit of a pet hobby. I had so many in pursuit of electronics that I regret that I am unable to get those great big thrills into words that give justice to the years of wonder and indescribable thrills.

Cordially yours,

John Oliver Ashton

Palo Alto, CA

[Excerpt of letter by John Oliver Ashton]

There is one man in the East who might assist you if you can approach him right. He is John Hays Hammond Jr. a millionaire who has his [ill] at Gloucester, Mass. His father was a Tesla supporter on the Robot. I knew many millionaires, but this one was a snob.

I palled with men like Earl Ovington on whose Bleriot Monoplane I installed my original system using the first counterpoise antenna in 1910 and while Earl soared at some 1500 feet over Mineola-Hempstead we carried on the first two-way radio from plane to ground, I at "H.Q." in Yonkers, Earl aloft in his "fly". He became the First Air Mail Pilot. He was a millionaire's son and close friend of Tesla.

Earl would put on spectacular displays of fireworks using a huge Tesla coil mounted to a platform over the crows at Old Madison Square Gaden and as he would let me venture forth on the glass platform take big sparks of terrifying length off a wand that I held in my hand which is turn jumped to the ball on the top of the Tesla coil. I soon found we had a daily matinee and evening show here for the electrical show duration and attracted vast crowds who expected to see us both electrocuted. Earl was a show-off and he loved it. I was a scared kid even though fascinated with the sparks that I loved.

Tesla would stand by with a paternal eye on us both and smile for he was somewhat of a showman himself as you have read. His famous parties at his lab for his millionaire friends were famous and Nick loved to get the lights low and put on eerie displays. I must confess that I tried to emulate him many times and it was fun.

My first wireless transmitter of any size was 10 K.W. open core transformer and to that I had an open gap and huge glass plate in oil condenser. With my huge antennas over Yonkers I could get the distance that envied the boys when I would work with ships in mid Atlantic. Prior to 1912 no license was required.

Dear Mr. Andersen:

Thanks for your note of the 14th. I have been busy with my bread and butter job here in applications engineering for an electronics jobber. As an older citizen it seems that the better paying engineering jobs are unavailable to us here. The electronics firms are staffed with youngsters who resent an oldsters experience.

I had a letter from Beta. I believe that I met Erwood once when I was seeking to buy some businesses for a wealthy client in Connecticut. I have suggested to him that he might obtain more definite information on the Big Oscillator through you or the Tesla Museum?

You might write to Mrs. Earle Lewis Ovington, Santa Barbara, California. She is the wealthy widow of my former friend in early day electronics and aviation in New York. Earle became famous as the First Licensed Air Mail Pilot. He and I had Bleriot Monoplanes at Garden City, L.I. in 1909 when they were beautiful little fairy moths that flew at 75 M.P.H. over the heads of the admiring crowds in Sundays much like a circus ar und a track with tall pilons as markers. The first radio two way set was installed in Earle's Bleriot"Dragonfly " at Garden City in 1909. It was a bread board affair. We had lotsof fun with it and pioneering the counterpoise antenna which is credited to two others who rediscovered it a year or more later . Although I became one of the first fliers of that day and was a naval flier in 1917 I quit that for radio as that has always been my forte. From the 1890's when I first met Tesla at the Garden in N.Y. and he gave dad and Earle and others a private showing of his radio controlled torpedo bpat I was thrilled with the

radio ideas. I hope to get some good cinnetced story on paper for posterity and documentary purposes so that the younger generation may know what it was like to thrill to the newsets of that day. I have Dr Lee de Forest and old friend and mentor to advise and encourage me. At 80 he is going strong with his newest Heat Machine. EARLE L. OVINGTON WAS ASST. TO TESLA ALSO A FINANCIAL BACKER IN 1895-1910.

I was with the O.S.R.D. and with the R.F.C. briefly as a consultant. I had original ideas to sell the F.B.I. and called there in Washingotn but could get no where. They know it all. Apparently they secure advance info on matters which they classify as "knowledge" but it is my belief that they have grabbed "knowledge" thet they don't know how to apply? A number of the so-called secret devices that they are using were old stuff years ago. The much talked of Wrist Watch Radio was built at our lab away back in 1926. Dr. Charles F. Burgess built the first portable in 1920. My friend Louis Pacent had it in his consulting office in N.Y.C. for years as a relic. Burgess and Louis have departed for greener fields beyond the vale, where I have an idea there is plenty of research to be accomplished too.

I am very glad to note of your progress toward a definite start on the Bulletin and the Tesla Journal. If I may be of assistance please let me know. I would like to help if I can?

I am in "a sort of a mess" here with a man whom I befriended here. He has a Mineral Ore Selector that separates any mineral from its gangue, electronically. The machine has great possibilities. I have managed to get some of the large mining companies interested. Then I introduced the inventor to men of means who backed him with a token allowance. He is a thorouvhly impractical business man and spent the money unwisley. The backers are "peeved" and will not invest more until he shows them all the machine workings.

As this inventor has been cheated before he is so suspicious that he refuses tp reveal "the whole secret" to his backers. He has applied for patents thrpugh a patent lawyer friend of mine whom I brought intothe picture. The backers, the lawyer and the C.P.A. who has the corporation papers can do nothing with the inventor who is stubborn and will not move unless he gets more money. It is an impasse that is embarassing to me. I am the one who got the whole matter under way and there is nothing that I can do now but try and assume a new backer to take over the present backers who want thier money back ($20,000). In the mean time the inventor runs all over, even to Mesaba-Duluth, Minn. at the beck and call of the mining companies who are doing their best to steal the idea if they can. The machine is said by big authorities to be one that will revolutionzie the whole mining process industry.

I am proposing that some one invest say $100,000 in a new company to take over the present one that can't get going due to "persanality trouble". If you would like more data on the machine let me know. It is an actuality-not a dream. It works. The model is here. The inventor has invested over $150,000 of his own money and is broke. That money was spent in research prior to the forming of the corporation. Let me know if you have anyone interested enough to want to see the machine and meet the inventor and investigate it thoroughly.

The lady you mention as having called upon O'Neil may have been Mrs. Fritz Lowenstein? He was with Tesla and a pioneer. There were a number of German sympathizers that Tesla knew. There was quite a fuss at the time of W.W. I, for my dad used to dine at a large German restaurent in N.Y. with a man whom he had befriended. (I might say in passing that my grandfather and my dad and I

all have have had a great trent toward befriending inventors and technical men.I believe I told you how Grandfather was the oreginal backer of Bell in Salem,but Bell made a flop pf the Harmomic telegraph and felt bad because Elisha Grey beat him. That"mistake"made Bell. He had lived at 336 Essex Street, a block away from the Sanders Mansion where he established his fisrt lab in the basement and later inthe attic, 336 Essex Street in Salem was built and occupoued by my family for five generations and grandfather was always helping others.Dad was of a similar stripe and knew so many of the inventors that Okenite and his wealthy telephone pioneer colleagues backed.) Well Dad used to dine in this German restaurant where he enjoyed the imported beer, and there he met this personable red-bearded young man who became his charge. The man spoke English with perfection and had a PH.D.(Heidleberg). He was in the oil business for some German company and dad helped him meet business men.Prior to the war I worked for D.E.B.E.G. and briefly for the Atlantic Communication Co [NAUEN-SAYVILLE TRANSATLANTIC STAT.] as a consultant I installed radio on the Argentine battle ships Rivadavia and Morena. I was in the N.Y. office and one some German ships under Seslig, Boehme, andothers. I knew men like Zennick and Braun and other leaders in Germany. The war broke out.I went into the navy and was forbidden to even mention thier names. Dad felt hurt because if his friend in the oil business who had returned to Germany. One day Dad was quizzed by the old F.B.I. and was pretty well peeved a tthe treatment a ccprd d him an established businexx man with two sons on the service and he let them know it too.They finally revealed that his friend who had visited our place in Yonkers was in reality one of the several

(5)

sons of the Kaiser and a Major General in the Army over there. I belive he was killed in action.

I will keep you informed as I can.

Sincerely,

John O. Ashton

John O Ashton

2261 St Francis Drive
Palo Alto, California
September 22nd, 1953

EARLE OVINGTON
FLYING SINCE 1911
SANTA BARBARA, CAL.

Santa Barbara, Calif.
November 16, 1953

Dear Mr. Anderson:

Thank you for sending me the brochure, which I have read with interest. I recall that my husband, at different times, spoke of Nicola Tesla as one of the greatest electrical geniuses that ever lived.

I regrest to say that I do not understand much about electricity. I am therefore taking the liberty of passing on this literature you have sent me to one of my husband's oldest and best friends, Dr. Fred Strong, who has been interested in high frequency almost all of his life. I am asking him to write you.

Thank you very much for your thought of me in this matter.

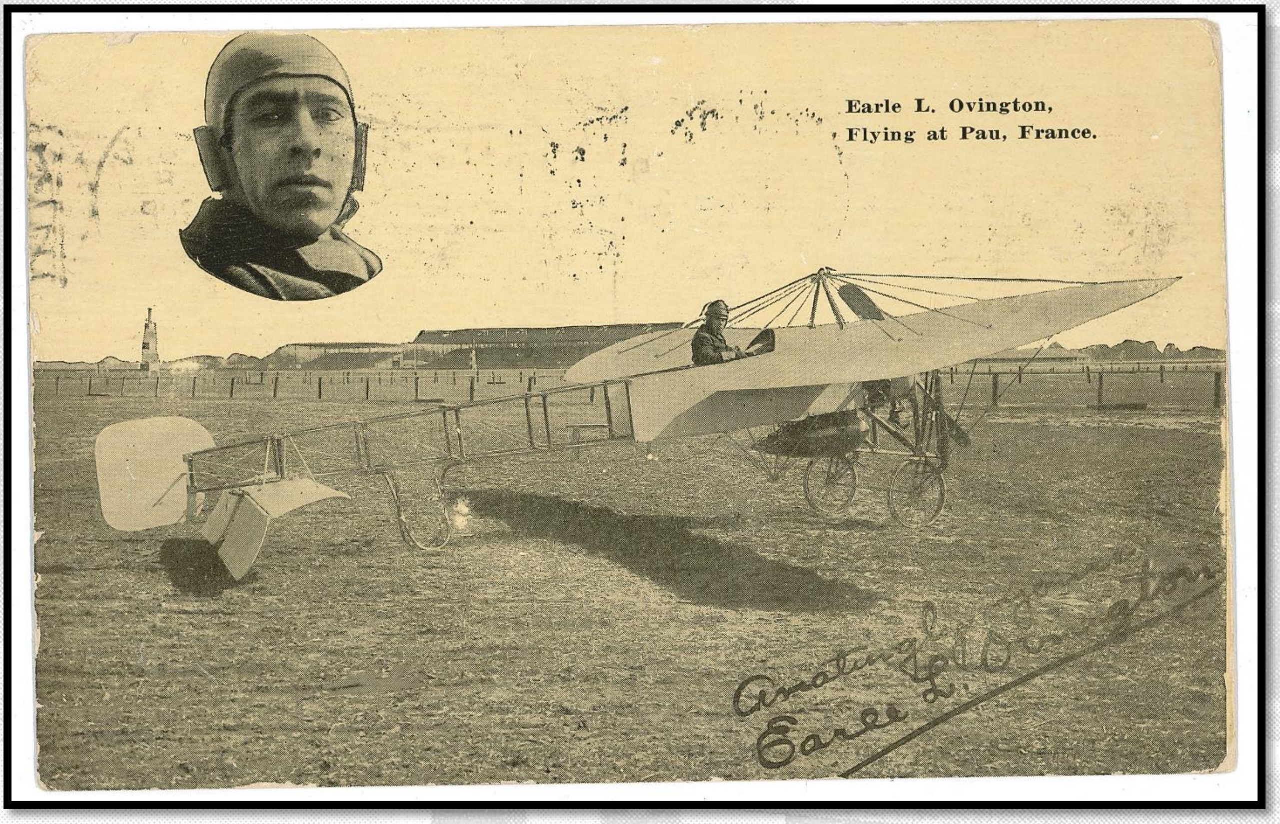
Most sincerely

adelaide Ovington

Adelaide Ovington

Cold Spring Tavern
Santa Barbara, Calif.

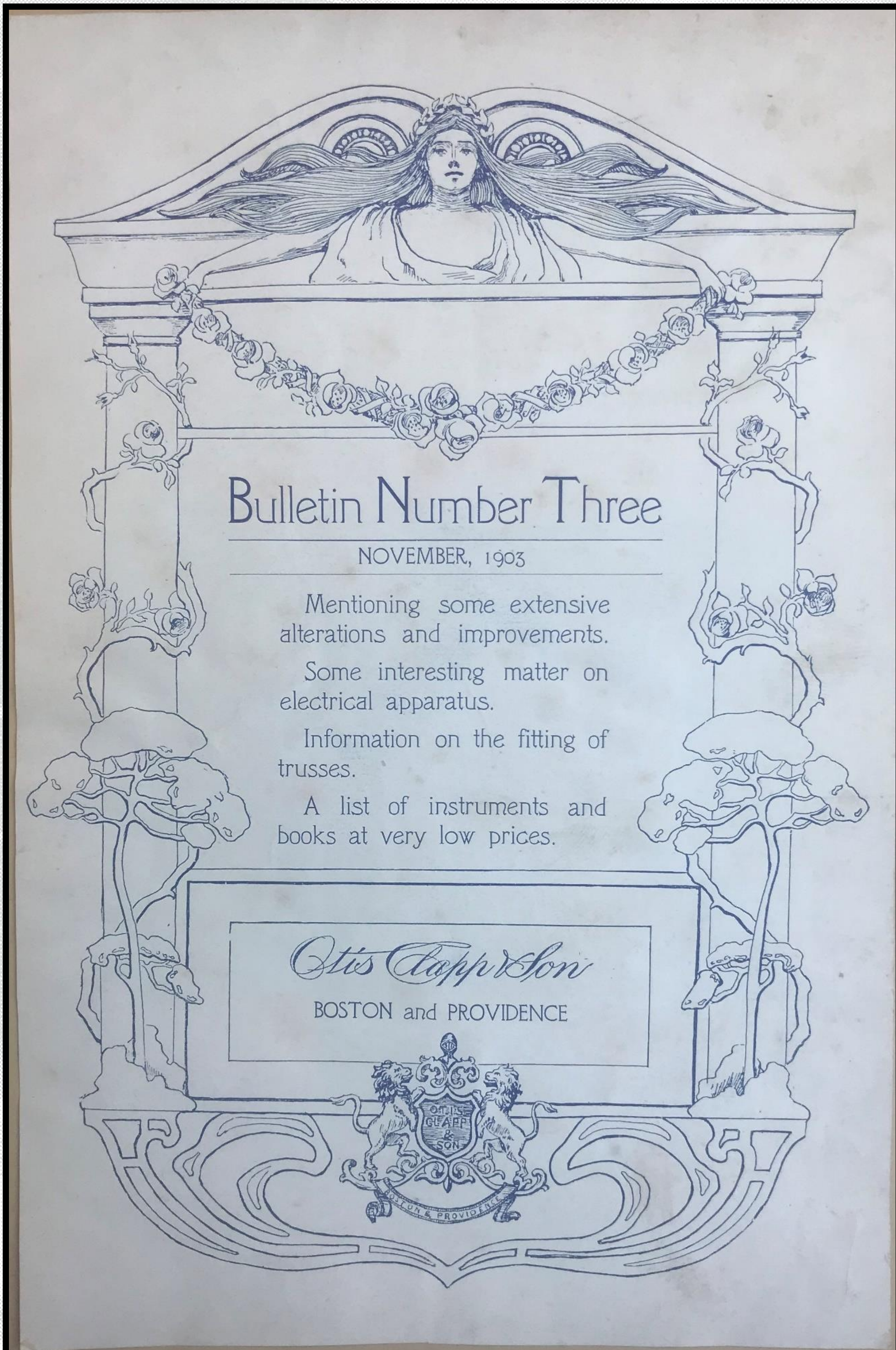




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July 4, 1908.



Bulletin Number Three

NOVEMBER, 1903

Mentioning some extensive alterations and improvements.

Some interesting matter on electrical apparatus.

Information on the fitting of trusses.

A list of instruments and books at very low prices.

Otis Clapp & Son

BOSTON and PROVIDENCE

The Story of a new Electro-Therapeutic Appliance.



The brilliant achievements of scientific investigators in the field of electrical science during the past decade have served to concentrate the attention of the medical profession upon the wonderful possibilities to be found in the field of electro-therapeutics. Although conservative members of the medical profession have ever been wary of experimenting in the treatment of disease by electricity, yet since the days of Gilbert and Franklin this important subject has been forcing itself more and more to the front, until many of the leading lights of the healing art are to-day numbered among the believers in its efficacy.

The wonderful discovery of Roentgen, made known to the world in 1896, gave a great impetus to the use of electricity in medical and surgical diagnosis, which bids fair to be surpassed by the perhaps greater serviceability of the X-rays as a therapeutic agent in the treatment of some of the most formidable diseases which afflict the human race. Finsen's discovery of the usefulness of the ultra violet rays in the treatment of various diseases has given an added impetus to the subject.

The Strong Static Induction and High Frequency Apparatus.

Among the first to experiment with the X-rays in this country, after the announcement of Prof. Roentgen's discovery, was a young medical student in the city of Boston who showed his genius by building for himself an apparatus for the production of the X-rays early in 1896. This student, Dr. Frederick F. Strong, now instructor in electro-therapeutics in Tufts Medical College, selected the Tesla or High Frequency type of apparatus for his experiments, and it was not long before he noticed that patients who were exposed to the X-rays generated by his apparatus were in many cases benefited in their general health. This led him to investigate the therapeutic possibilities of electric currents of high frequency and high potential with astonishing results. Up to date he has treated several hundred cases, many of which had proved refractory to other forms of treatment, and in the majority of instances beneficial results have followed.*

During this time he made a number of improvements in his apparatus and many ingenious adaptations for the therapeutic application of High Frequency currents, among others being the use of vacuum electrodes and other methods of treatment through glass. Dr. Strong has discovered many interesting things in the course of his investigations and has succeeded in adapting his apparatus to a variety of uses.

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*Dr. Strong is now writing a book giving in detail the result of his work, which will soon be put in the hands of a printer for publication.

twenty breaks per second as ordinarily found in the Resonatur types, and even only two or three per second as found in H. F. attachments for static machines, such as Piffard's Hyperstatic Transformer. The enormous increase of the rate of condenser discharge in the Strong apparatus manifestly increases the power of the apparatus in like ratio.

Another unique feature is the air rheostat which permits of an exact regulation of the dosage. Still another feature of much value is the device for regulating the frequency and potential of the apparatus, which is accomplished by alterations in the capacity, inductance and resistance. These are placed at the command of the operator by means of specially constructed high tension switches placed on one end of the machine.

A point of much importance in this class of apparatus is the question of insulation. This, we believe, has been satisfactorily solved by Dr. Strong, who has spent many hours in his laboratory experimenting with different materials and has finally obtained a substance of surpassingly greater resistance than oil, and, therefore, an ideal insulator. Nor is the apparatus left to depend upon insulation, being so constructed electrically and mechanically as to be subjected to the least possible amount of electrical strain when in use.

The apparatus is manufactured under the direct supervision of Mr. Earle L. Ovington of the Massachusetts Institute of Technology, who was connected with Edison's laboratory for over two years. He personally tests every instrument, subjecting it to double the strain while testing that it will be called upon to endure afterwards.

High Frequency Therapeutics.*

The physiological effects of high frequency currents are chiefly exercised upon the vaso-motor system causing a flushing of blood through the peripheral capillaries, opening up the sweat glands and relieving local congestion. The blood becomes oxygenated and uric acid is oxydized into urea and elimination of waste products greatly increased. There is a marked germicidal action due to what is termed "electric ozonization," which is the result of the large amount of ozone generated by high frequency currents and carried into the tissues by electric bombardment. This is of much value in the treatment of infected sores, tubercular ulcers, chronic skin diseases, etc. There is an increased elimination of $C.O_2$. and respiration is favorably affected. There is also an undoubted anesthetic action when the current is concentrated over a small area.

It is obvious that an agent of such valuable and varied physiological effects must be useful in the treatment of a large number of diseases. Among those in which it has been found of special value are diabetes, gout, chronic rheumatism, obesity, hysteria, neurasthenia, insomnia, headache, anæmia and chlorosis, dyspepsia, atonic dilatation of the stomach, colitis, hemorrhoids, chronic constipation, prostatitis, neuralgia and pulmonary tuberculosis. Herschell has obtained excellent results in the treatment of gastric ulcer, chronic gastritis and chronic catarrh of the intestines.†

Among local diseases benefited by high frequency treatment may be mentioned lupus vulgaris, lupus erythematosis, chronic eczema, acne rosacea, psoriasis, pityrasis, sciatica, pruritis, rodent ulcer, trachoma, prolapsus and fissure of the anus, etc.

There are certain essentials to be taken into consideration by the physician about to purchase high frequency apparatus. Many inefficient machines of little value are on the market, and the purchaser should not be misled by low price or unwarranted claims to purchase a cheap or inferior piece of apparatus. A first-class instrument should be capable of giving 500 milliamperes or more of current in the secondary circuit and should supply a heavy spray of from 5 to 8 inches in length. It should be adjustable as to tension and frequency, as the low frequencies of five or six hundred thousand oscillations per second are only suitable for X-ray work, the most efficient frequencies for therapeutic work ranging from a million to a billion per second.

The Strong Static Induction and High Frequency Apparatus is designed with especial reference to the above mentioned requirements which have been found by leading workers to be necessary to obtain first-class therapeutic results. The price of the apparatus with therapeutic attachments is $350. The X-ray attachment is $25 extra. The Ultra Violet attachment is also $25 extra. These can be obtained at any time after the apparatus is installed.

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* For further details of the therapeutic uses of high frequency currents see Chisholm Williams book on the subject. Price, $2.75. For sale by Otis Clapp & Son.

† Herschell Manual of Intragastric Technique, London, 1903.

Static Electricity.

In his private practice Dr. Strong has succeeded in securing all results from his apparatus that can be obtained with a Static machine. The value of this fact can only be appreciated by those who have experienced the disheartening and unsuccessful effort to make a static machine work in humid weather. To those who have been accustomed to rely upon the cumbersome static machine with its fragile glass plates and its susceptibility to atmospheric conditions, this neat, compact and handsome apparatus of Dr. Strong's seems a wonder. That an instrument which can be attached directly to any incandescent lighting circuit and is not affected by moisture or temperature should be capable of producing the static breeze, spray or spark, or produce effects similar to the static induced and wave currents seems almost beyond belief. Yet all this and much more can be accomplished with this new apparatus. For that reason it is called the "*Strong Static Induction and High Frequency Apparatus.*"

Among the late therapeutic appliances designed by Dr. Strong for use with his apparatus may be mentioned the *Vacuum Head Spray,* the *Combination Fluorescent Electrodes,* and the *Adjustable Condensing Effleuve Electrode,* with attachments which enable the operator to use a spark through glass or the effleuve directly against the body of the patient, either through the clothing or against the bare skin. He has also devised a unique apparatus for the inhalation of ozone generated by high frequency discharges. This apparatus is constructed so as to eliminate the disagreeable nitrogen fumes, which is a great improvement upon the ordinary types of ozone inhalers.

Ultra Violet Rays.

Another late addition to Dr. Strong's apparatus is an attachment for generating pure Ultra Violet Rays of great power and quantity. This attachment is a modification and improvement of the condenser spark lamp used by Gôrl of Nuremburg, in which advantage is taken of the fact that the condenser spark is very rich in ultra violet light. In the Gôrl lamp the discharge from a pair of leyden jars is carried to a series of three or four small iron balls placed about one-eighth inch apart. The discharges of current are necessarily intermittent and follow each other at comparatively long intervals. In Dr. Strong's improvement the discharge from a condenser of much greater capacity is utilized in such a way as to obtain a continuous arc between the electrodes. Hence the ultra violet rays are much more powerful and of surpassingly greater quality.

X-Rays.

The X-rays produced by this apparatus are steady and powerful, seeming to possess in a large measure the actinic power of X-rays generated by a powerful coil, combined with the penetration noticeable in X-rays generated by large static machines with a great number of revolving plates. The result is an X-ray that gives splendid definition for fluoroscopic work, with excellent results in radiographic work, the length of exposure being much shorter than is necessary with even the largest static machine.

High Frequency Currents.

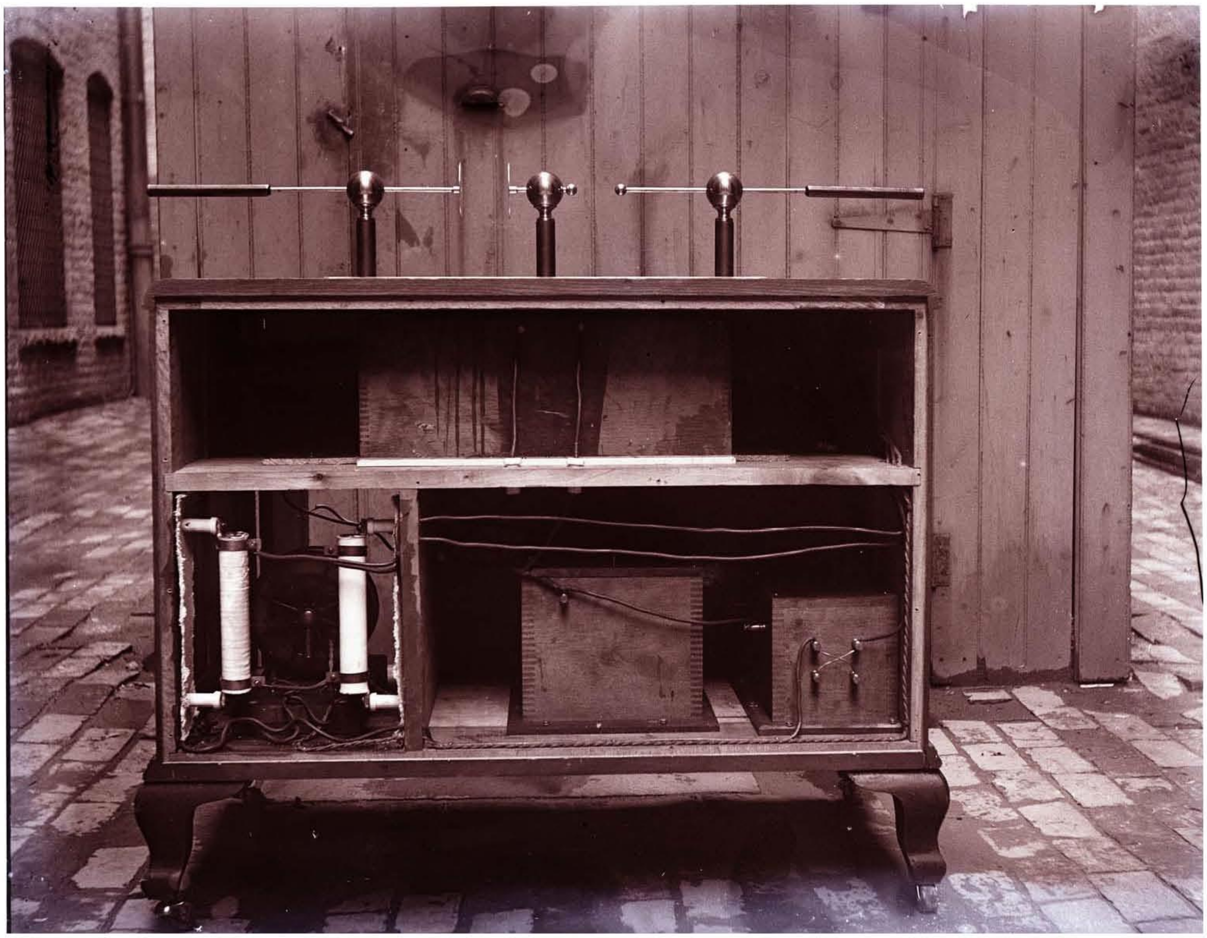
Although Morton used high frequency currents therapeutically as far back as 1881, the power and tension of his currents were very low, being obtained simply from the discharge of a pair of Leyden jars and were by him denominated "Static Induced Currents." In 1890 D'Arsonval commenced his experiments with high frequency currents and obtained some very encouraging results with a high frequency solenoid. In 1893 Oudin devised his "Resonatur," which is the instrument now almost universally used abroad for the production of high frequency currents. With this class of apparatus some remarkable results have been obtained by European electro-therapeutists.

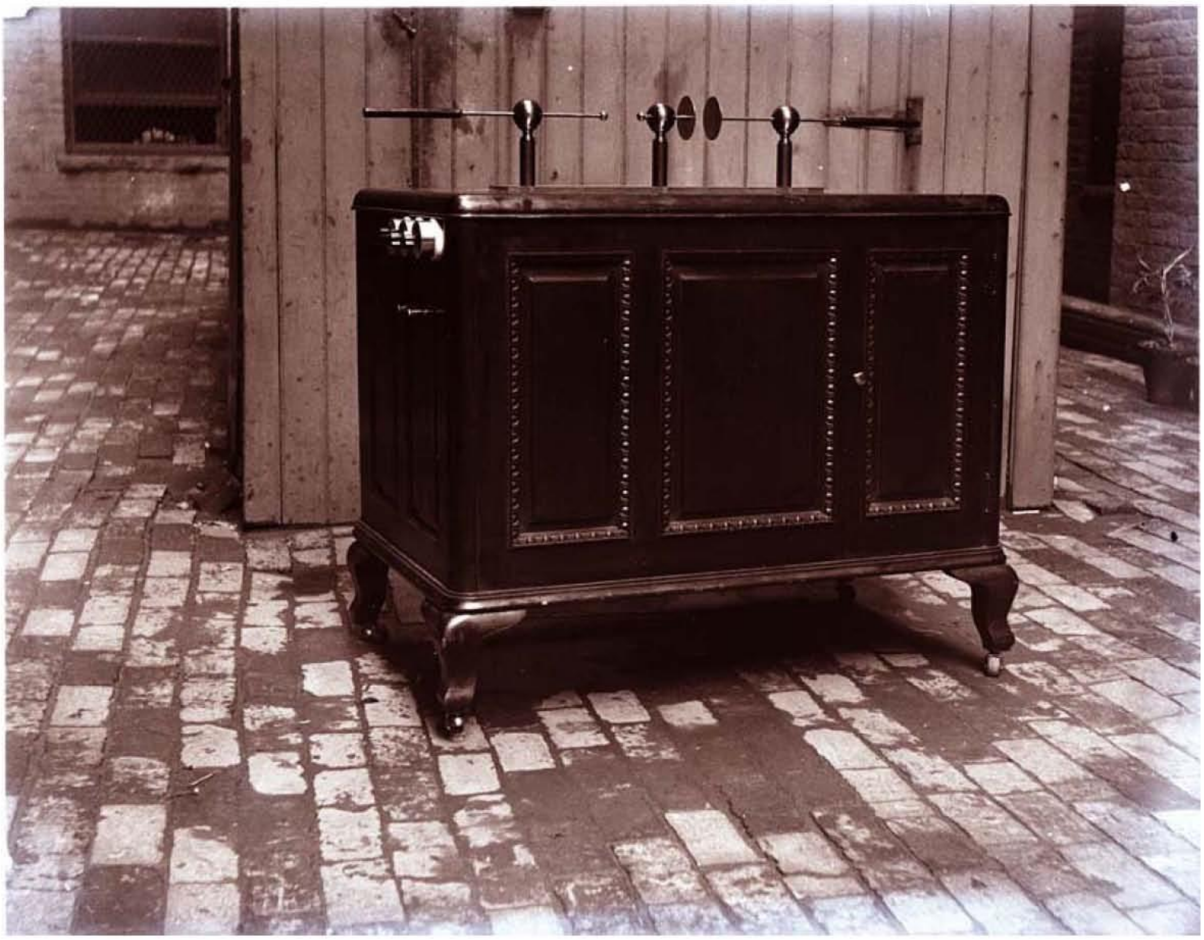
Unique Features.

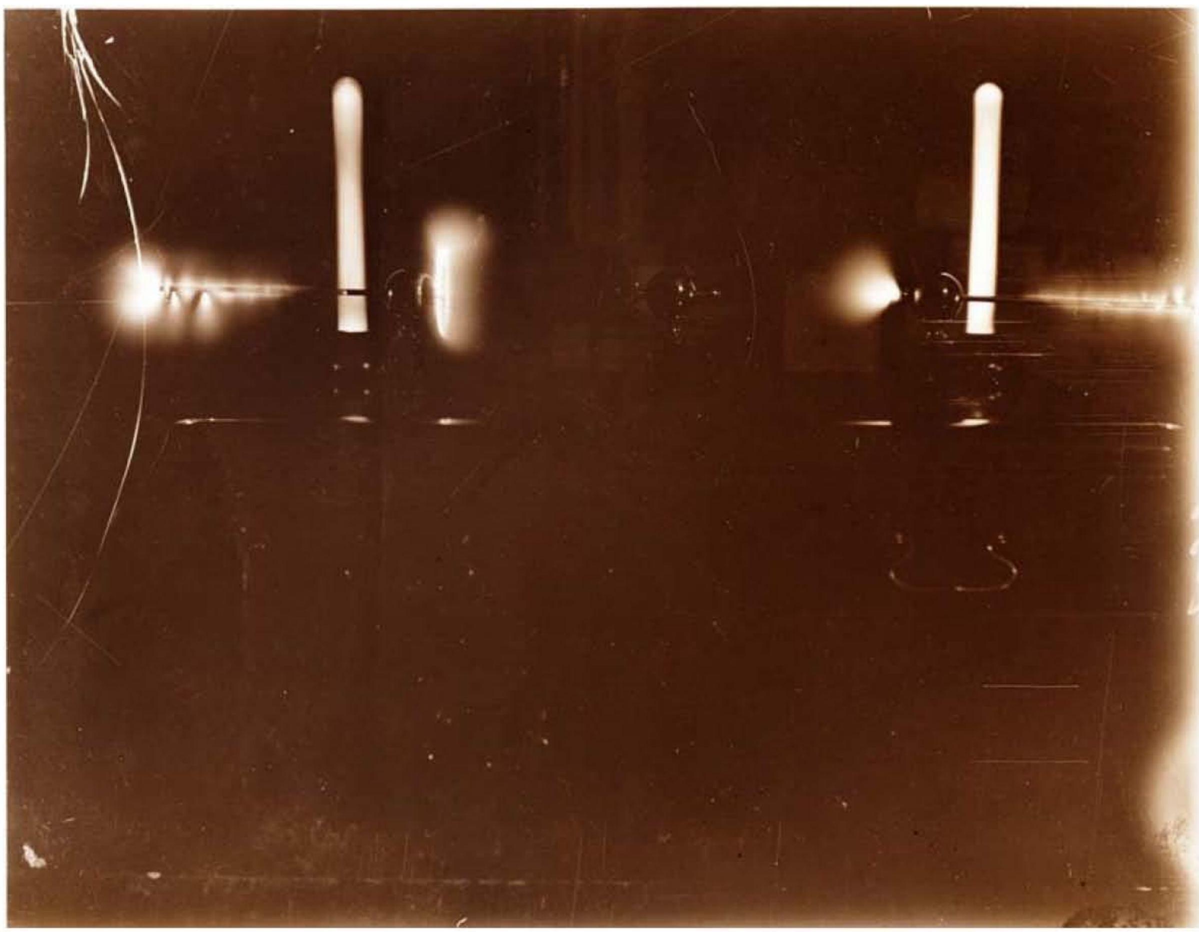
Many notable improvements upon this type of generator have been made in the Strong Static Induction and High Frequency Appratus, however. Among others may be mentioned the spark gap which gives over a thousand breaks of the condenser discharge per second as against ten or



Original photographs of Earle Ovington, developed from glass plate negatives by Robert Campbell.



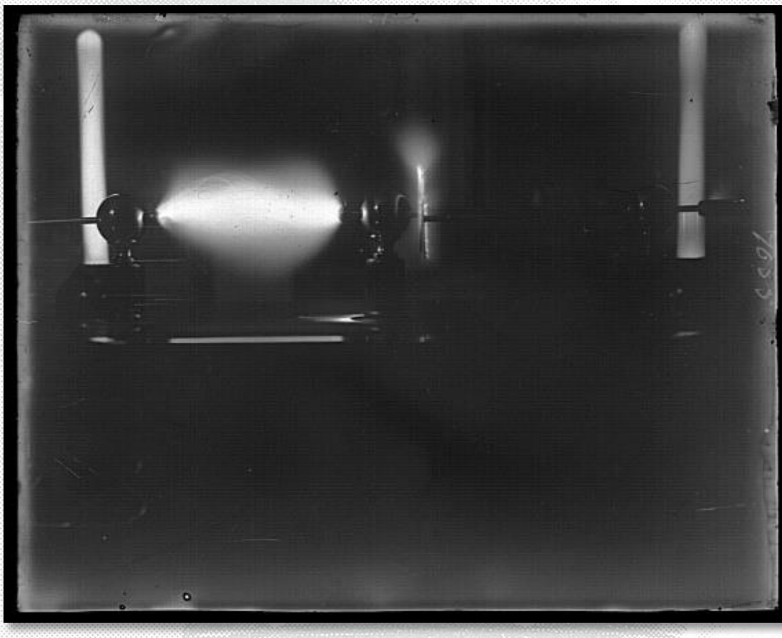


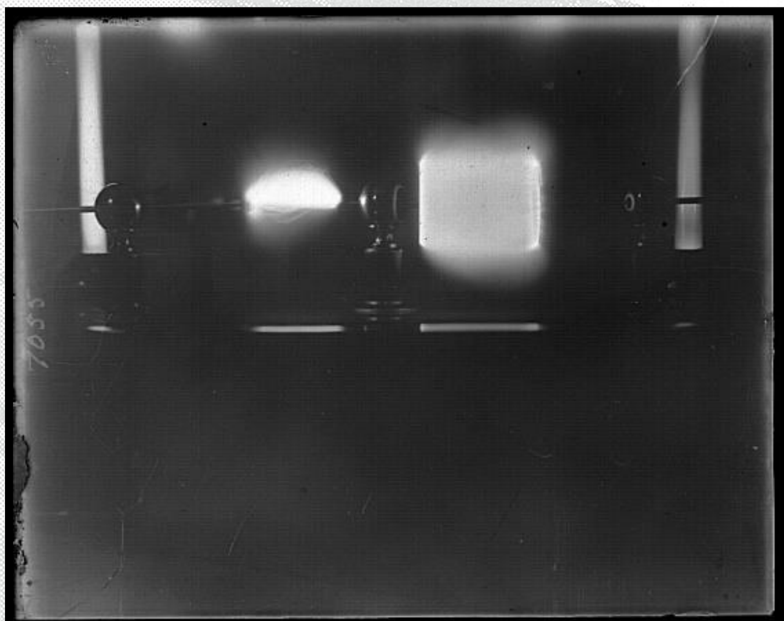


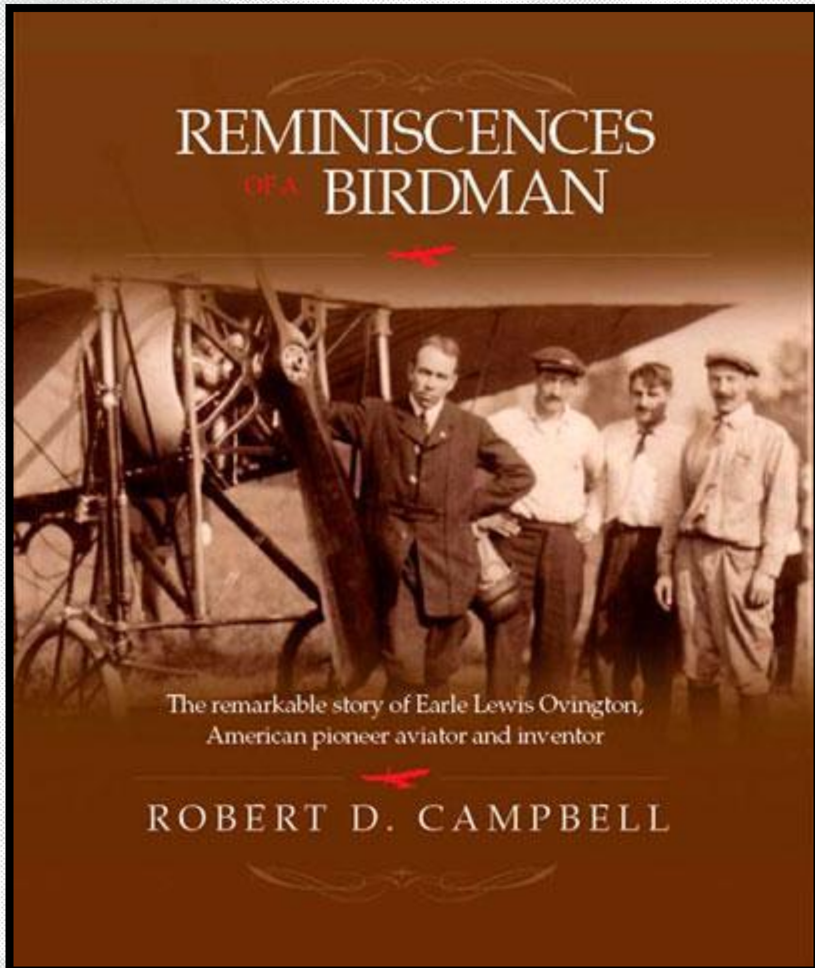


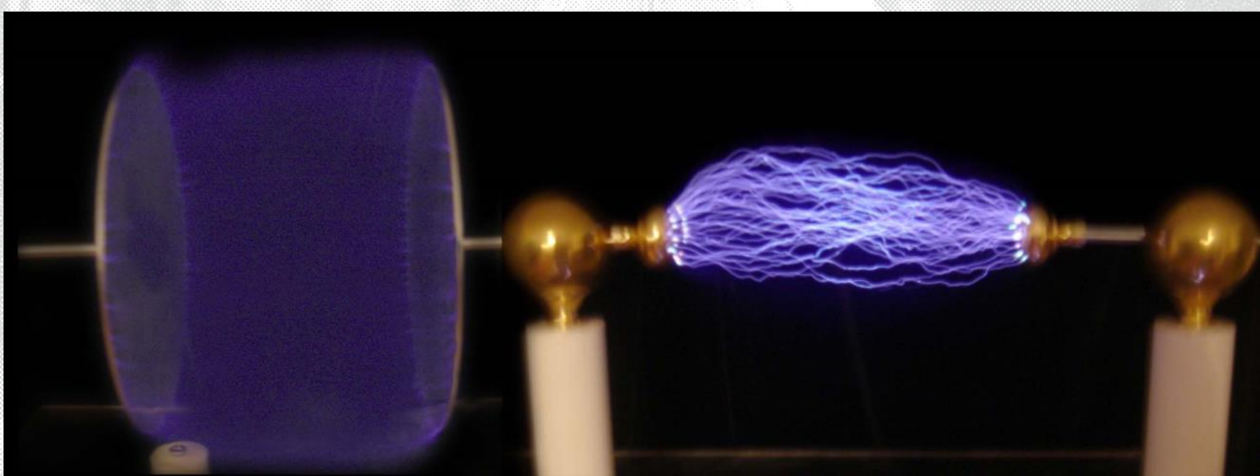


Full output of Strong-Ovington Coil, showing both sparks and effuve.
All photos are from Robert Campbell.



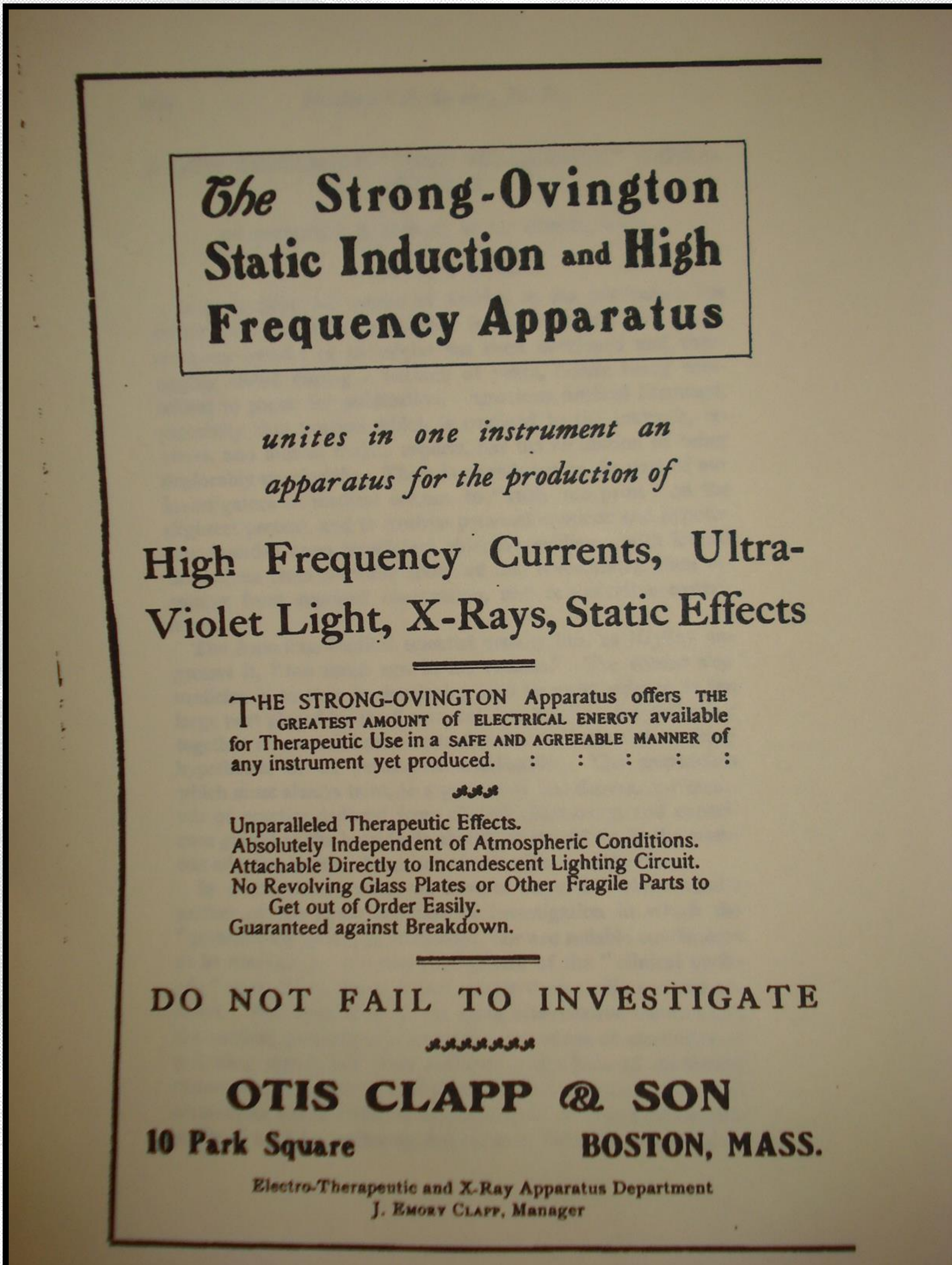



REMINISCENCES
OF A BIRDMAN
The remarkable story of Earle Lewis Ovington, American pioneer aviator and inventor
ROBERT D. CAMPBELL





Robert Campbell, author of Reminiscences Of A Birdman, Living History Press. One of the most beautiful books, all of Earle Ovington's original glassplate negatives were hand-developed using traditional techniques by Bob. The machine is a replica I built of the Strong-Ovington coil especially for this book.



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A NEW SYSTEM OF "HIGH FREQUENCY" THERAPEUTICS.

BY FREDERICK F. STRONG, M. D., BOSTON, MASS.

Introductory Article.

In presenting this series of articles to the profession, the writer feels no little satisfaction in the consciousness that a complete system of technique has been developed and thoroughly tested during a number of years, before being committed to paper for publication. American medical literature, especially that portion which is confined to the journals, reviews, and annual society reports, has the reputation of being deplorably unscientific. There is a tendency on the part of our investigators in medical science to "rush into print" on the slightest pretext, and to confuse personal opinions and hypotheses founded upon insufficient objective evidence, with logical deductions from carefully compiled and co-ordinated data resulting from repeated observation, and conservative experiment.

The American medical scientist usually has, as Kipling expresses it, "too much ego in his cosmos." The reason that medicine is so slow in developing into an exact science, is the large part played by the "personal equation" in the gathering together of material as a basis for the deduction of working hypotheses, or of permanent conclusions. The empiricism which must always taint, to a greater or less degree, our methods of practice deduced from clinical observation and experience gained at the bedside, is absent, or should be, in the methods adopted in other branches of scientific investigation.

In electro-therapeutics, we have a "hybrid" which admits neither of the exact methods of investigation in which the "personal equation" is eliminated, nor are reliable conclusions to be obtained by the sole employment of the "clinical methods," upon which most of our present therapeutic systems are based. The skepticism of the more conservative members of the medical profession in regard to the value of electricity as a healing agent, has been justified by the host of conflicting statements, rash claims, and imperfect deductions of misguided enthusiasts whose methods might have been correct and appropriate if used in gathering information from the observations

of daily medical practice, but which lacked the impersonal objective methods of pure physical science.

The modern science of electro-therapeutics which is slowly emerging from the confusion of misstatements and personal ideas which have, until recently, made up the literature of the subject, is being evolved through the careful laboratory work and conservative clinical studies of those investigators who combine the careful training of the scientist with the more strictly personal and intuitive perceptions, which are so characteristic of the successful physician.

In venturing to offer to the profession what he feels justified in denominating a "new system of high frequency therapeutics," the writer believes that the important results, which it is the purpose of these papers to describe, have been tested and verified by strictly scientific methods, and statements and deductions founded solely upon personal belief or preconception, have been eliminated in every case.

The system comprises the following contributions to the physician's equipment:

A form of high frequency current, differing from those produced by the resonators, solenoids, and transformers in use at the present time, being more powerful, regular, of greater frequency, and higher vitalizing or health-producing characteristics, and being susceptible of a much wider range of applicability and general usefulness, than any other single therapeutic agent that is known at the present time.

Second. An apparatus for the economical generation of the above current, adapted for use on the usual electric lighting circuits, capable of producing all effects obtained by the use of the static machine, the faradic, sinusoidal and cautery apparatus, and giving therapeutic results impossible to obtain from these, or from the usual high frequency resonators and solenoids. In addition to the above, the new apparatus will yield X-rays equal, and in many ways superior, to those from any coil or static machine, and is the only satisfactory X-ray machine that has yet been produced for use with the alternating electric lighting current. When we consider that heretofore physicians living in cities supplied with the alternating current, have been obliged to employ expensive motor generators and current reversers in order to operate X-ray apparatus, the scope of the new machine in this particular field may

be partially realized. It is also adapted to the production of the "ultra-violet light," and yields rays of greater power than those of any other apparatus employing the condenser discharge for "ultra-violet" generation. The perfected machine is the only therapeutic high frequency apparatus on the Tesla principle. The details for the construction of an apparatus such as the writer is now using, will be given next month, in the second article of this series.

Third. A simple system of regulation, by the use of which currents of high frequency may be controlled and modified for the production of the effects ordinarily obtained from the static machine, faradic coil, etc. European authorities on high frequency therapeutics state that muscular contractions cannot be produced by the currents of this nature, yet the writer's system of regulation enables one to produce muscular contractions and massage effects of any desired intensity and frequency.

Fourth. A large number of special methods adapted to facilitate the application of the high frequency current to different parts of the body for the production of a wide range of effects. Chief among the instruments devised by the writer for the above purposes, during the past eight years, are the various electrodes, inclosed in, or consisting of, glass. The discovery of the value of treating through glass was made by the writer early in 1897, and demonstrated in the latter part of the same year, in a number of lectures and papers presented at medical society meetings. Vacuum electrodes were first suggested and employed by the writer in the autumn of 1897. The first regularly constructed vacuum electrodes for the therapeutic application of high frequency currents were made and demonstrated by the writer in an illustrated lecture before the faculty and students of Tuft's College Medical School, in February, 1898, and similar electrodes have been used by him continuously to the present time. While the writer's numerous devices and inventions for the generation and use of high frequency currents have been familiar to Boston physicians for some years, there are many others to whom the statement that vacuum electrodes, for example, were devised and employed in giving high frequency treatments during 1898, will come as somewhat of a surprise, more especially as in 1901 a patent was granted to certain parties for vacuum electrodes, and the drawings in the

patent specifications were strangely similar to electrodes that the writer had been using for a year or more prior to the date of the patent. A somewhat similar coincidence occurred within the last few months, when Dr. Mount-Bleyer described in the Medical Examiner a series of experiments with "ultra-violet light," in which he illustrates a special monopolar vacuum tube, having a quartz window opposite an aluminum cathode, and describes it as the "Mount-Bleyer Ultra-violet Tube," to be used with a static or high frequency apparatus for the generation of ultra-violet light in treating skin diseases. Had Dr. Mount-Bleyer looked up the Patent records, he would have found the description of a tube almost identical with his, in the specifications of a patent taken out by the writer, over a year ago, and assigned to Mr. Frank H. Swett, who made the first tubes of this kind from the idea suggested by the writer. In the next article the writer will describe in detail the technique of his various methods of high frequency treatment, and the electrodes that are used in connection therewith.

Fifth. Finally, the writer will present a summary of over four hundred cases treated by him during the past eight years, and in which high frequency currents were employed therapeutically, with almost invariable benefit to the patient. The final article of this series will be devoted exclusively to clinical reports selected from a large number of cases, embracing a wide range of pathological conditions. The results of treatment have been so invariably beneficial, and in some cases, so very remarkable, that the writer has withheld their publication until the present time, when a number of physicians are using the apparatus of the type described, and employing the writer's methods in treating their cases, and arriving at similar conclusions regarding the value of the writer's system of high frequency therapeutics.

Next month's article will consider the details and principles involved in the construction of the writer's apparatus. The use of the X-ray tube, excited from the high frequency apparatus, will also be considered in the next article, and several entirely new points that have been evolved through the use of this combination, will be explained.

A NEW SYSTEM OF HIGH FREQUENCY THERAPEUTICS.

BY FREDERIC F. STRONG, M. D.

(*Continued from page 163.*)

It was my intention to devote this paper to a detailed consideration of the physical nature of high frequency currents and the various methods by which they may be produced. But the rapid increase in the number of physicians who are using the perfected form of the apparatus and who are anxious for instruction in the technique and working details thereof, has led to the change of the order of presentation of certain divisions of the subject, and I shall, therefore, pass at once to the discussion of practical working details.

The machine known as the Strong-Ovington Static Induction and High Frequency Apparatus is the perfected form of generator that I have used for the past seven years in the successful treatment of a wide range of diseased conditions. The original apparatus was completed during the spring of 1896, and was designed solely for the generation of the X-ray. It was one of the first powerful X-ray machines that was constructed in this city, and while cumbrous, inefficient, and crude, it nevertheless gave a current of great voltage and frequency, differing in no essential point from that which is obtained from the perfected apparatus. The improvements that have been made have been directed to the perfection of mechanical details, efficiency of action, etc.

The original machine consisted of a large step-up transformer, containing eight pounds of number 36, silk-covered wire in the secondary coil, the primary consisting of layers of number 12 wire, wound around an iron core, 3x12 inches. The secondary was wound in thin disks or sections, like the majority of induction coils, and the completed apparatus (immersed in oil) gave a good seven and one-half inch spark when used as a Ruhmkorf coil. This transformer was designed for use on the 104 volt alternating current, the secondary being connected to the two sides of a condenser formed of sixteen pairs of glass plates, 5x7, coated on one side with tinfoil, and built up in the usual manner; this was also immersed in oil. My original Tesla coil was made from a three-inch pasteboard mailing tube, eight inches long, evenly wound

with a singing layer of smooth linen twine, the depression between the adjacent convolutions forming a spiral groove, in which was wound a layer of number 40, silk-covered, magnet wire. Ten turns of heavy, rubber-covered number 10 wire were wound around a three and one-half inch pasteboard tube, and slipped over the above secondary coil. The Tesla transformer thus completed was immersed in oil, and the ends of the number 40 wire of the secondary coil were brought out through heavy glass tubes, and connected with terminals with sliding rods, similar to those on a small static machine. The ends of the large wire, which formed the primary, were brought out in a similar manner, and connected to the two sides of the condenser. A small spark-gap (consisting of two brass balls about one-sixteenth inch apart) being included in the circuit in series with the primary coil. In actual use it was found necessary to employ some device to cool the air which formed this gap, as the heavy discharge of the condenser caused the balls to become red-hot, thereby destroying the oscillations and forming an arc. After trying various devices, an apparatus was adopted, consisting of a metal wheel, bearing a number of wings, which were revolved in front of a brass ball, the discharges taking place between the latter and the moving metal wings. This device has, in the writer's opinion, never been excelled for this particular purpose, and is employed, in a greatly improved form, in the modern perfected machine. This apparatus was designed by M. E. Cate, of the Knott Apparatus Company, who were the first manufacturers to bring out a practical high frequency apparatus for X-ray work. Their apparatus possessed the same serious defect as mine—the necessity of using a heavy and cumbrous oil tank for the insulation of the working parts.

As the principles involved in the original machine are identical with those upon which the perfected apparatus is based, one explanation can be made to serve for both. The apparatus (in common with all high frequency generators in which the Tesla principle is employed) is designed to operate on an alternating current. The usual form of alternating current that is used for incandescent lighting, is 104 volt, and 60 cycles per second (a cycle is a complete wave, and consists of two alternations). In my perfected apparatus a small rotary converter is employed when it is desired to operate the machine on a direct or continuous current. When the physical nature of high frequency currents, and the various methods that are employed in their production, are considered, the writer will explain why it is that high frequency currents generated by the Tesla principle, which starts with a low voltage alternating

current, is most perfectly adapted for use in an apparatus for therapeutic purposes. For the present, it will suffice to say that the Tesla method is the only one by which a smooth, continuous oscillation can be obtained.

It is somewhat amusing to read in one of the European text-books, that: "High frequency therapeutics are unknown in America, except in a few instances where an attempt has been made to obtain these currents by the crude and inefficient Tesla method, which has been thoroughly tested and discarded as impractical by the European investigators." As a matter of fact, the current from the perfected apparatus bears the same relation to the discharges produced from the European solenoids, resonators (all of which are excited by the secondary current of a Ruhmkorf coil), as the rich vibration of the organ pipe bears to the weak staccato produced by intermittently striking the same note on a piano.

In the perfected, as well as in the original form of the apparatus, there are three essential factors, two of which are used to raise the voltage, while the third increases the frequency of the original alternating current.

The 104 volt current, alternating 120 times per second, passes into the primary of the step-up transformer (the electro-magnetic inductor) and induces in the secondary a current of similar frequency, but of about 15,000 volts. This flows into the condenser, which is like an elastic reservoir, and which suddenly discharges when the pressure becomes sufficient to break down the barrier of air at the spark gap. By carefully tuning the primary of the Tesla coil, by adjusting the number of turns to the capacity of the condenser, oscillatory discharges will be set up every time the pressure in the condenser breaks down the air gap. There may be thousands, or even millions, of these oscillations for every initial discharge of the condenser. There is, therefore, a high frequency current passing through the primary of the Tesla coil and across the spark gap, but the voltage still remains 15,000. In Europe a current similar to that just mentioned is produced in the D'Arsonval solenoid, and is used principally to produce increased tissue combustion, and to burn up uric acid and other waste products. The more important effects of the high frequency currents on the nerves and vasomotor system are not obtained without further increase in the voltage of the current. In the Tesla system this increase in voltage is brought about by the inductive action of the primary on the secondary coil of the Tesla transformer. This is an illustration of electrostatic induction, no iron being used in the high tension coil. A potential of between one and two million volts is obtained by the final transformation in the Tesla coil of the perfected apparatus; this is coniderably higher than was obtained from the earlier forms of my machine.

If the edge of a stiff card be pressed upon the rim of a slowly revolving toothed wheel, a series of sharp clicks will be produced. If the speed of rotation be gradually increased, a point is reached at which the individual clicks or impulses are no longer perceptible to the ear, being replaced by a sustained vibration or musical tone. This critical point varies somewhat with different people. In like manner, by increasing the rate of vibration, the pitch will be raised to such a high note that the range of sensibility of the aural apparatus is exceeded and the sound is no longer perceived. If we connect the muscles of each leg of an anæsthetized animal to an alternating current dynamo of suitable power, we will observe a sharp contraction at every alternation as long as the latter are not too rapid. As the frequency increases, however, the intensity of the contractions decreases until a point is finally reached at which the muscles cease to respond, although the voltage and alternations may be greater than at lower frequencies. From a physiological or therapeutic standpoint, we may speak of an alternating current as high frequency when the number of impulses is above the point at which muscular contractions cease. The statement that the higher the frequency, the more superficial is the action on the body, is entirely erroneous. Surface action is a peculiarity of the static charge alone. The more kinetic the nature of the current, the more deeply does it penetrate the tissues. This subject will be more fully considered in the next paper.

In developing the system of technique which is used in connection with my apparatus, a number of special instruments and electrodes have been designed by the writer. Although generally known in this city, the fact that the writer was the originator of the vacuum electrode, and the various methods of treatment through glass, is not generally recognized. The first vacuum electrodes were demonstrated before one of the local medical societies in 1897, and I have used such electrodes constantly ever since.

The technique which I have developed for the therapeutic use of high frequency currents, as produced by my apparatus, comprises the use of a number of distinct methods, which may be grouped under the following heads:

I. Methods involving the use of glass electrodes (treating through glass).

(*a*) Vacuum electrodes.

*(*b*) Hollow glass electrodes, containing solutions of salt, carbon powder, metal rods, etc.

(*c*) Sparks from metal points upon plate glass held in con-

* In a subsequent article will be described and illustrated a large number of different electrodes which have been devised by the writer for use in special cases or conditions. Similar electrodes have been invented and described by foreign workers within the last year or two.

tact with the body. (Of special value in nervous dyspepsia, constipation, etc.)

2. Methods involving the use of the "Tesla brush discharge," "high frequency spray" (the "effluve" of the foreign investigators).

(*a*) Discharge from single metal point.

(*b*) Discharge from metal brush or multiple point.

3. High frequency bath, by the use of the "condenser couch" of D'Arsonval, or by use of insulating platform and "canopy electrode."

4. "Wave current" or "vibratory massage." Bipolar treatment with metallic electrodes in contact with the patient, a variable air gap in series with the latter.

5. Sparks, or arcs, between the surface of the body and a metal point connected with one terminal of the machine. (Used only for counter-irritant and cautery work.)

To facilitate the employment of these methods of treatment a set of terminals have been employed for the past five years which have come to be recognized as a distinguishing feature of the apparatus. The terminals of the high-tension coil are brought up through rubber pillars which support sliding rods, one of which (at the right) ends in a small brass ball, while the other, at the left, terminates in a brass disk (*a*) Midway between these is a third pillar called the "Dummy" having a brass disk fixed upon its right side, and a ball upon the left. By closing the gap between the disks the discharge may be studied as an arc between the stationary and sliding ball. With these balls widely separated the arc breaks up into a series of spark-like effects resembling the discharge of a static machine. When the gap is from two to four inches in length, however, a perfect arc or singing flame is produced which gives out appreciable heat. This can be demonstrated by lighting a stick of wood in the discharge, or by holding the hand a few inches above it. By closing the gap between the balls and drawing the disks apart, a different form of discharge is produced,—the beautiful and spectacular "Tesla brush discharge," consisting of a fine rain of purple hair-like lines completely filling the gap between the disks and radiating on all sides.

As this article has already been unduly extended, the details of the various methods of using the Tesla currents for therapeutic purposes will be described in full in the next paper of this series.

(*To be continued.*)

A NEW SYSTEM OF HIGH-FREQUENCY THERAPEUTICS.

BY FREDERIC F. STRONG, M. D., BOSTON.

(*Continued from page 216.*)

The complex nature of high-frequency currents, especially when considered in their relation to the human organism, renders it well-nigh impossible to explain theoretically many peculiar effects observed in the course of their therapeutic application. Our knowledge of the laws of vibratory forces and their inter-relation is at present so meager that we can do little more than observe and record clinical data, reserving for the present any hypotheses or theoretical explanations that may suggest themselves to us. We may, however, learn much that will be of value to us by a purely physical study of the subject, especially in connection with the laws governing the relation of *capacity* and *inductance.* The patient subjected to treatment by currents from the writer's apparatus and according to his system of technique, may be regarded as one side of a condenser connected with a source of oscillating current. The opposite plate of this condenser being represented by whatever electrode or capacity is connected to the opposite terminal of the apparatus. In all the methods comprised in the writer's technique it is essential that there should be an air-gap or other insulating medium in series with the patient and the terminals of the high-frequency coil. In other words, all the different forms of application producing effects similar to those obtained from the static machine, faradic, galvanic, and sinusoidal currents, are dependent upon the formation of an insulating layer or dielectric in series with the patient and the Tesla coil, and upon the *variation, partial destruction,* and *periodic reconstruction* of this dielectric, according to the effect that is desired. It has not been previously recognized by investigators of high-frequency currents that by artificially or mechanically interrupting the flow of the oscillatory stream it is possible to produce all the effects of muscular contraction, tissue drainage, and local stimulaton that may be obtained by any other form of interrupted current such as the faradic, interrupted galvanic, static wave-current, sinusoidal current, etc., and that these effects are supplemented and augmented by the underlying specific physiological action of the high-frequency

oscillations, which increase tissue combustion, facilitate the removal of waste, and leave the body actually richer in potential nerve energy than before the commencement of the treatment. An effect which is of undoubted value in many inflammatory conditions is the periodic inflex and withdrawal of the blood and lymph streams resulting from the application of the "Morton wave-current" from a powerful static machine. The writer claims that similar effects can be produced from his high-frequency apparatus by the use of the metallic electrodes, one of which is connected to the right-hand terminal of the machine,—the electrode itself being pressed upon the affected or inflamed area,—while the other electrode, which may be held in the hand or applied at some indifferent point, is connected with the middle post or "dummy," the contractions being controlled by adjusting the distance between the two plates until a brisk brush-discharge plays between them (see the article in the April number; also refer to illustration under "New Apparatus" in that number). The contractions produced in this way are more or less irregular, but fully as effective as the more truly periodic impulses of the static wave or the interrupted galvanic. Physicians accustomed to the latter modalities complain that the high-frequency wave-current "feels as if something were out of order," or "like a 'burn' faradic apparatus." This is quite true, and while the physiological effect is the same, the suggestive effect upon the patient is not equal to that produced by more rhythmic impulses.

The writer has entirely overcome this defect within the last few weeks by placing a metronome with a loop of aluminum wire attached to the pendulum at one side and midway between the brass discs of the high-frequency apparatus. When the pendulum is away from the path between the discs no contraction is felt, but as the loop of wire is carried between the discs by the opposite swing of the metronome a brush-discharge of gradually increasing intensity is produced and as gradually obliterated. The sensory effect resulting from this method is as rhythmic, pleasant, and effective as that obtained from any electrical apparatus with which the writer is familiar.

Within the knowledge of the writer there is no apparatus (*a*) that will produce such a volume of powerful X-rays from the same amount of electrical "wattage"; (*b*) that will maintain such a steady ray and hold the tube at a given vacuum

for such a great length of time; (*c*) that has relatively so little heating effect and drain upon the life of the tube; or (*d*) that combines the maximum destructive action upon morbid growths with the minimum amount of superficial inflammatory action—as the X-ray which may be obtained from either form of the writer's perfected high-frequency apparatus. The writer has a tube which retails for $10.00 that has been in almost daily use for over a year, and which shows no evidence of severe use other than a slight blackening from volatilized platinum. More will be said in this connection when discussing the results of clinical work and report of cases treated.

(*To be continued.*)

REPORT OF THE COMMITTEE ON CURRENT CLASSIFICATION AND NOMENCLATURE.*

(*Continued from page 298.*)

WERBER SECTIONALLY INSULATED DISCHARGE ROD.

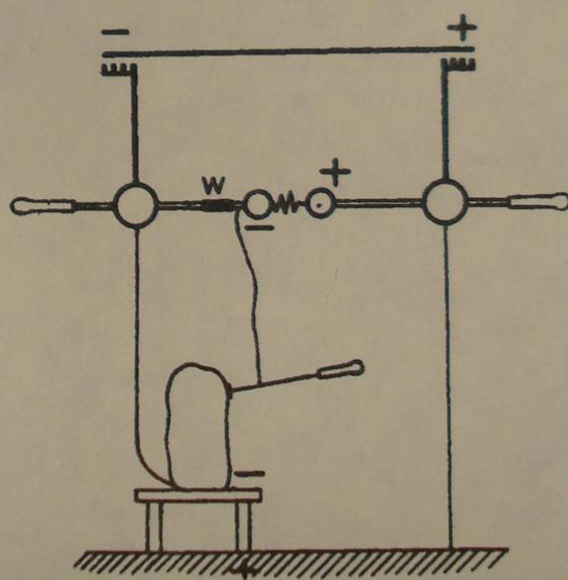


FIG. 11

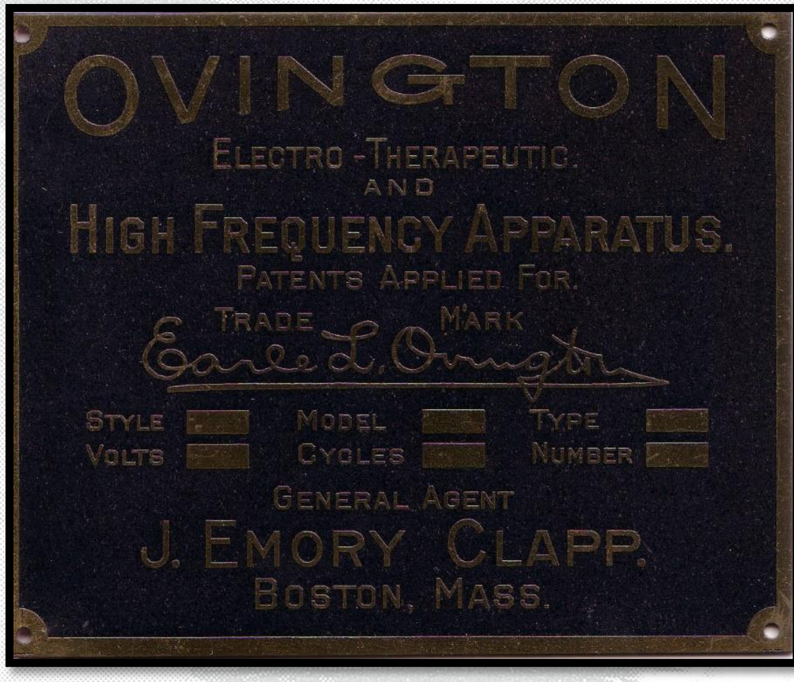
This apparatus is described in the JOURNAL OF ADVANCED THERAPEUTICS, Vol. II., p. 293, May, 1902. One of the dis-

* Read at the Thirteenth Annual Meeting of the American Electro-Therapeutic Association, at Atlantic City, September 24, 1903.

HIGH FREQUENCY CURRENTS.

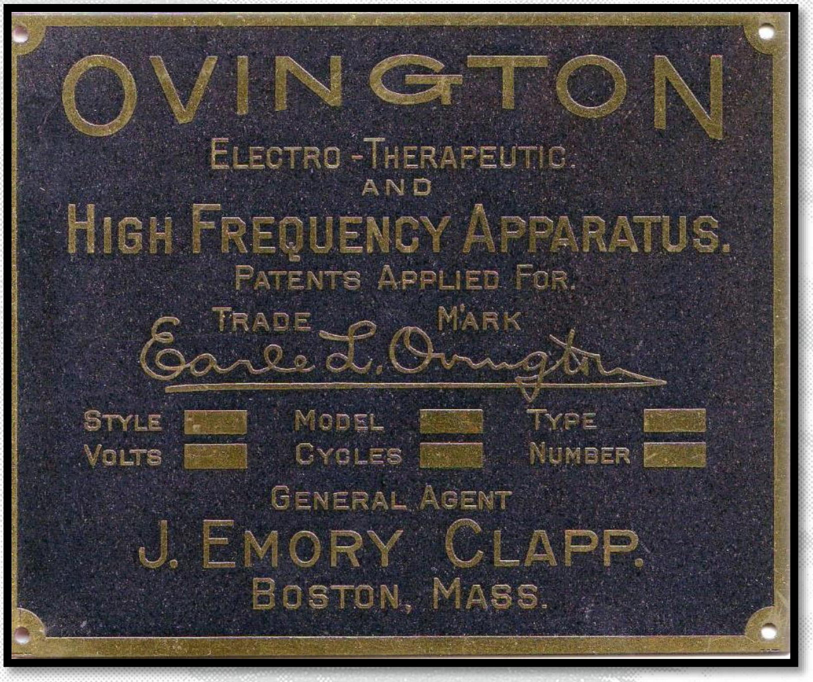
BY EARLE L. OVINGTON.

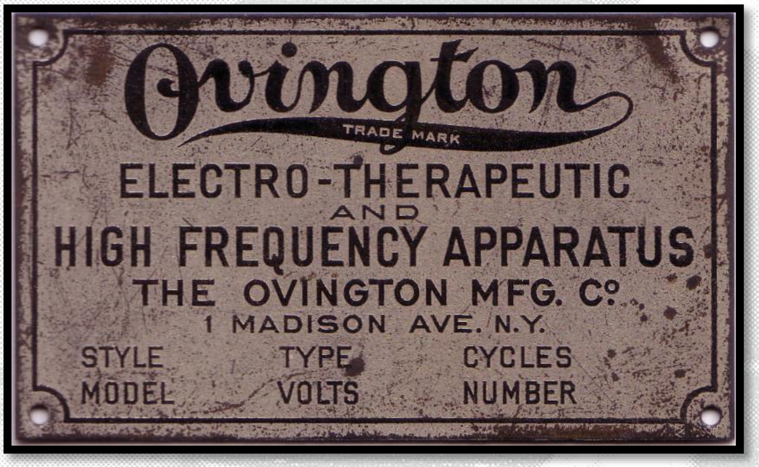
Reprinted from THE JOURNAL OF ADVANCED THERAPEUTICS,
July, 1906


OVINGTON
ELECTRO-THERAPEUTIC
AND
HIGH FREQUENCY APPARATUS.
PATENTS APPLIED FOR.
TRADE MARK
Earle L. Ovington
STYLE MODEL TYPE
VOLTS CYCLES NUMBER
GENERAL AGENT
J. EMORY CLAPP.
BOSTON, MASS.


OVINGTON
ELECTRO-THERAPEUTIC
AND
HIGH FREQUENCY APPARATUS.
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HELD AT

CHICAGO, ILLINOIS, JUNE 26-JULY 1, 1905

EDITED BY

CH. GATCHELL, M. D., SECRETARY

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PUBLICATION COMMITTEE
1905

SOME PECULIAR PROPERTIES OF HIGH FREQUENCY CURRENTS

Earle L. Ovington, Esq.
ASSOCIATE MEMBER AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

To the average physician the term "high frequency currents" is anything but definite. The term has been so often misapplied that there is little wonder it is so generally misunderstood. In this paper it will be my aim to give an exact idea of what high frequency currents are and to illustrate experimentally some of their peculiar properties.

What is generally called the "alternating current" is a current of approximately sixty cycles per second, or, as it is sometimes called, 7200 alternations per minute. This means that in one second the current passes through 60 complete periods or cycles. Let us assume the current starts at zero value (see Fig. 1) and increases in a positive direction along the curve AB. When the current reaches B it has attained the maximum positive potential. It then decreases along the line B C until it again arrives at zero as shown at C. Continuing along the line C D E the current traces a path below the zero line of the same shape and size as that above, arriving finally at the point E on the zero line ready to commence another cycle. Along the line A B C is one alternation and along the line C D E is another. The complete curve A B C D E is a cycle. Hence there are two alternations, one positive and the other negative, to every cycle. Electricians always speak of so many "cycles per second" or "alternations per minute," and never reverse the terms. This is sometimes confusing to the non-technical mind as the manufacturer uses the more scientific term "cycles per second," while the local electrician usually refers to his current as so many "alternations per minute."

In commercial electric lighting and power work 25 cycles per second is called a low frequency current, while 133 cycles per second is considered a high frequency. To the physicist and manufacturer of therapeutic high frequency apparatus, however, 133 cycles per second is a low frequency. The latter consider a current one of high frequency only when it changes its direction thousands of times per second. These extremely rapid rates of vibration are not obtained by mechanical means, an electrical arrangement being far more satisfactory.

The questions have often arisen: What is a high frequency current? How are we to draw a line of demarcation between currents of low and high periodicity? I suggest the following definition of

a high frequency current, considering these currents from the standpoint of the physician.

A high frequency current is one which is produced by the disruptive discharge of a condenser.

In suggesting the above definition I do so with the full understanding of the fact that under certain conditions the disruptive discharge of a condenser may be of comparatively low frequency, or may even not oscillate at all. These conditions, however, are rarely met with in practice and hence our definition is suitable for every case with which the physician will probably have to deal.

Assuming then that by the term high frequency currents we mean currents obtained by disruptively discharging a condenser, let us see how such currents are actually produced for therapeutic use.

There are three methods of generating therapeutic high frequency currents, the D'Arsonval, the Oudin and the Tesla method. The machine illustrated (Fig. 2) is so designed that any one of these methods may be used at will, that is, either D'Arsonval, Oudin or Tesla currents are produced. I shall try to show you wherein they differ.

In this paper I shall ask pardon for the frequent mention of my own machine. This frequent mention is necessary, furnishing, as it does, all the various currents necessary for the following experiments.

For an illustration let us entirely disconnect the Tesla coil regularly furnished with the apparatus, and lead the heavy oscillatory current, which ordinarily excites the primary of this coil, outside the cabinet. This result is accomplished by means of switches F and P in Fig. 2. Now connect this heavy oscillatory current to a coil, which is simply three turns of electric light wire wound into the form of a circle two and a half feet in diameter. By connecting metallic handles to the two extremities of the circle of wire and turning on the current, we obtain the high frequency current of D'Arsonval. This is nothing more nor less than the drop in potential across this crude coil caused by currents of extremely high frequency circulating through the coil. In practice the D'Arsonval current is obtained from binding posts D D in Fig. 2, and regulated with handle G. The frequency of the D'Arsonval current is high, but the voltage is necessarily comparatively low, being limited by the potential of the transformer charging the condenser, and governed by the length of the spark gap.

Oudin added what he called his "resonator" to the solenoid of D'Arsonval and thereby raised the potential of the currents produced. Since we cannot obtain something out of nothing, this rise in potential is at the expense of amperage. The Oudin current has a higher voltage than the D'Arsonval current, but correspondingly less amperage. A rough model of an Oudin resonator consists of a single layer of wire, the length of which, however, must be carefully

proportioned to the wave length and frequency used. Let us see how we can increase the voltage by this simple device.

Place this Oudin resonator within the D'Arsonval coil and connect the lower end of the resonator to the coil itself. Turning on the current we notice the high potential discharge issuing from the top of the resonator. Bring a vacuum tube within the vicinity of the discharge and we notice it glows brightly. The high frequency currents have set up an intense electrostatic field in the neighborhood of the resonator and it is this rapidly varying electric stress which induces the currents within the tube and causes it to glow. Oudin currents are obtained from the machine by attaching the terminal Y to a special socket on the right hand side of the cabinet (not shown in Fig. 2). Oudin currents are then obtained from the other terminal Z.

It is but a short step from the arrangement of Oudin to that employed by Tesla. Simply disconnect the lower end of the resonator from the heavy wire coil and bring the plane of this coil so that it passes through the center of the solenoid of finer wire. We now have the bipolar coil of Tesla, the heavy coil being the primary winding and the finer wire the secondary. Although there is no visible connection between the primary and secondary windings, we see that powerful high frequency currents are induced from one coil to the other. Connect an X-ray tube to the secondary of this crude Tesla coil and we notice the characteristic green fluorescence of the Crookes' vacuum. It is rather strange, when you come to think of it, that these X-rays are being obtained from a simple coil of wire which is separated by fully one foot of space from the source of energy. When experimenting with high frequency phenomena, however, one becomes accustomed to remarkable effects and looks for them as a matter of course. Of course, in practice, this crude device is inefficient and inconvenient. Powerful Tesla currents are obtained for therapeutic and X-ray results from the terminals Y Z after detaching the special Oudin connection previously mentioned.

As to the relative merit of the D'Arsonval, Oudin and Tesla methods of current generation, I would say that it depends upon the use to which the current is to be put or the disease that is to be treated. When heavy amperage is essential the D'Arsonval method recommends itself, while for monopolar work requiring a higher potential the Oudin method proves more efficacious. As far as all around work is concerned, and for X-ray production, the Tesla method is by far the most appropriate. Each current has its use, however, and it is therefore better to have all at your disposal.

Now that I have shown the three methods by means of which high frequency currents may be generated, let us consider in detail one, and in my opinion the most important, of these methods. I shall now describe how a sixty cycle ordinary street lighting current of 100 volts may be transformed into a high frequency current of over a million volts and oscillating over a million times in a single

second. I shall use the Tesla method for this illustration, since it is the one employed in the most modern highfrequency apparati of great power. This transformation is not the result of a single process, but consists of three separate and distinct transformations. We will now consider these in detail.

Referring to Fig. 3 we have here the wiring diagram of the Tesla circuit. It will be noticed I have marked the alternating current mains "low voltage, low frequency." This is the commercial alternating current which usually has a periodicity of 60 cycles, and a potential of approximately 100 volts. If the direct current only is obtainable a rotary converter is used to convert the direct current into the more desirable form of electricity.

The alternating current is now passed to the primary winding of a high potential transformer which changes the 100 volt current to one having a maximum potential of about 30,000 volts *but does not alter the frequency.* The current is still a 60 cycle current. This is the first step in the transformation of our low potential, low frequency current to one of high potential and high frequency. Notice the first step increases the voltage only, and leaves the frequency unaltered.

In the second step of the transformation the periodicity is increased, while the voltage is left unaltered. The high voltage, low frequency alternating current is led from the secondary of the transformer (Fig. 3) to a condenser of suitable capacity. In effect this condenser may be considered a large number of Leyden jars such as are employed with static machines. The purpose of this condenser is to store up electrical energy at a comparatively slow rate and liberate it rapidly, that is, as a disruptive discharge. Referring again to Fig. 1, say the condenser charges at an even rate along the line A B. The potential at the terminals of the condenser, and hence at the two terminals of the spark gap, rises until the insulating layer of air between the spark gap balls breaks down due to the intense electric stress. A discharge across the gap now takes place and the stored up energy of the condenser rushes across the gap.

To the unaided eye this discharge across the spark gap appears to be a single spark, but in reality it is composed of a large number of smaller sparks or discharges. In fact the discharge is oscillatory in character, surging backwards and forwards millions, and in some cases billions of times per second. These rapid discharges slowly die out, due to damping caused by heating and other losses. When the discharges have diminished in intensity, or entirely stopped, the spark gap assumes its original condition of high resistance. This allows the condenser to again become charged to a high potential and the above process is repeated.

An analogy to illustrate the charging of a condenser would be the case of a spring steel rod, one end of which is clamped in a vise and the other left free to vibrate. If this rod be drawn aside and suddenly released, it will oscillate to and fro until it finally comes to

surface. Bjerknes demonstrated this experimentally with his famous resonator experiment. The human body, however, is not a good conductor of electricity as compared with a metallic wire and hence the action of high frequency currents with respect to a metallic conductor forms no criterion as to their behavior with respect to the human body which has a comparatively high ohmic resistance.

The skin effect in conductors decreases as the resistance of the conductor increases, and at the high resistance attained by the human body there is little doubt that the currents penetrate to the innermost portions of the conducting medium. How high frequency currents accomplish the results they are daily accomplishing, both in this country and abroad, with all sorts of apparatus, is a thing not explained by those who uphold the theory that these currents are superficial in their action.

I take this opportunity of introducing to the medical profession a new gap for high frequency apparatus. The construction of this device is so unique, and its operation so remarkable, that I think a description of it is not out of place in a paper of this character.

Most physicians have no doubt heard about the new mercury vapor lamp which was introduced a short time ago by Mr. Peter Cooper Hewitt. Some have possibly seen this new light, as it has been quite extensively adopted in photographic studios and to some extent used as an advertising medium. It is in the form of a tube about three feet long and one and one-half inches in diameter. The light emitted is rather disagreeable for some purposes, being practically monochromatic in character and almost entirely lacking in the longer wave lengths, such as red.

Some time ago my attention was attracted to this new device and it occurred to me to use it as a spark gap for high frequency apparatus. I later learned that such attempts had been made but for some reason or other the old form of spark gap was preferred. In the course of my experiments it became apparent why the new device had not been universally adopted. Under certain conditions its operation was ideal but unfortunately these conditions were not the conditions usually met in practice. To be more explicit the vapor gap worked well when a large amount of energy was used but was unsteady and erratic when currents such as ordinarily employed, were passed through it.

Now it so happens that the ordinary spark gap, composed of conducting electrodes separated by an intervening dielectric, operates very satisfactorily on light currents but fails completely when the current is increased beyond a certain well defined point. Fortunately what one gap lacks the other possesses and vice versa. It occurred to me to combine the two and thus get an ideal device. I did this and after considerable experimenting evolved the form I here describe. The gap is simply a glass bulb into which is sealed two platinum leading-in wires. A small pool of metallic mercury covers each of these wires. In operation the electric stress at the

surface of the mercury increases until ionization takes place and a bridge of mercury vapor is formed. This mercury vapor forms a low resistance path for the oscillatory currents but immediately regains its initial high resistance upon the diminution of the electric stress at the surface of the electrodes. The gap is perfectly noiseless and operates with absolute steadiness.

There are a great many advantages of this new spark gap, or interrupter, over the old device. In the first place almost any amount of energy may be passed through it without ruining the oscillations. Those who have had to deal with high frequency apparatus, know that the spark gap has been the one part of the machine which was liable to cause trouble. If anything went wrong, this device was the first to receive attention. This new spark gap does away with all these difficulties. I do not hesitate to say that an apparatus equipped with this new gap could be started going and left operating for three months, day and night, and during all this time it would perform its function perfectly. This is a pretty strong statement but many experiments and observations demonstrate the truth of it.

The machine here illustrated is equipped with this new mercury vapor gap, a switch being provided by means of which the vapor device may be thrown out of use and the ordinary gap employed in its place. I shall now describe some experiments to illustrate the relative efficiency of the two spark gaps.

Turning the Frequency Changing Switch (F in Fig. 3) on the machine to HIGH let us turn on the current. As long as the energy passing through the gap is small the ordinary device works very well but it fails almost completely when we turn the Extra Power Switch which greatly increases the current flowing through the machine. Now the way manufacturers and designers surmounted this difficulty was to greatly increase the size of their condenser. In this machine this is accomplished by turning the Frequency Changing Switch to LOW, and a great increase in power is obtained. With a small condenser working on a high frequency and heavy power, the ordinary spark gap is practically worthless. If the condenser capacity be increased the power of the apparatus is increased, but unfortunately an increase in the capacity of the condenser means a decrease in the frequency of the oscillatory currents produced. The problem for the designer was to obtain the necessary power and still keep the frequency high.

At this point the mercury vapor gap comes to our rescue. Thus we turn this switch and thereby put the vapor gap in circuit. Proceeding exactly as we did before, the oscillations are not destroyed as was the case when the ordinary gap was employed. Furthermore I wish to call attention to the fact that even on the low frequency the energy of the machine has been greatly increased by the introduction of this new gap. Turn the Frequency Changing Switch to LOW and we get a greatly increased power of the discharge.

With the ordinary gap the condenser is charged from one to

four or five times on each alternation or half cycle of the current wave, depending on the amount of energy used to charge the condenser. If more energy is applied with the idea of charging the condenser more rapidly, or if the condenser capacity is decreased in order to raise the frequency, the oscillations are almost entirely destroyed and the output of the machine greatly reduced.

With the mercury vapor gap these defects are not present. A small condenser capacity may be used and a powerful current without destroying the oscillations. The result is a high frequency current of enormous periodicity and large output. I have succeeded in charging a condenser as many as one hundred times on a single alternation or half cycle of the current wave. This is no less than 12,000 times per second! Each one of these 12,000 condenser discharges oscillated at the rate of over a million times per second! This certainly is high frequency.

Let us consider an experiment which will show in a beautiful manner the rate at which the condenser is being charged and discharged. Let us take a thin vacuum tube which is so arranged that we can whirl it in a circle while it is being illuminated by the high frequency current. If we hold this tube in the vicinity of one terminal of the apparatus, it glows with what appears to be a steady light; of course this light is not steady, as it is produced by a vibratory current. If we now whirl the tube in a circle and separate the images which follow each other with great rapidity, the number of groups of images will equal the number of alternations of the current per second, that is, twice the number of cycles. The number of images per group will show how many times the condenser charges and discharges on each half cycle. Of course each one of the separate images might be further decomposed and shown to be a collection of a number of weaker images corresponding to the actual oscillations of the current. We would have to employ a different means than here used to make this last separation, however, as the current oscillates at such an enormous frequency.

Using a large condenser capacity and low frequency with a small amount of charging energy, we notice that the condenser charges and discharges only once on each alternation or half cycle of the current wave. As we increase the charging energy we see two images to each group, which indicates the condenser is charged and discharged twice on each alternation. Keeping the charging potential constant and slowly increasing the energy passing through the transformer, we notice we can charge the condenser any number of times at will. As the energy is still further increased the images become irregular. This is the point where the ordinary spark gap begins to fail to perform its function of causing the current to oscillate regularly. We have now arrived at a point when the charging energy is too great in proportion to the other constants in the circuit and poor oscillations result. This is where the mercury vapor comes in. Put this new gap in circuit and we see that the images are again perfectly regular. Increasing the charging energy only

increases the number of images and in no way makes them irregular. A further increase of energy makes it impossible to count the images with the crude method we are using. If we could count them, and they are easily counted with a more refined method of observation—we should see they were perfectly uniform and regular. I think this demonstrates the advantages of the mercury gap over all other forms of current interrupters for high frequency apparatus.

In the foregoing description I have endeavored to give a description of what I consider the best method of generating currents of high frequency and potential. I have started with a current having a potential of only 100 volts and a periodicity of 60 cycles and gone through the processes by which this current is transformed to one having an extremely high potential and enormous frequency. Of course, I have only considered a simple case but the principle is the same, however complicated the modification of the apparatus.

Over ten years ago Nikola Tesla astonished the world with his wonderful experiments employing currents of high frequency and potential. He passed large quantities of energy through his body with only slight sensory effects, and performed other startling experiments which clearly demonstrated that electricity of this nature did not behave as did ordinary currents. Since Tesla's early demonstration, we have learned much regarding the peculiar properties of what he termed "alternate currents of high voltage and great frequency." Let us now consider some of these peculiar properties, considering as a source of energy the machine here illustrated, which is known as the Ovington Electro-Therapeutic and High Frequency Apparatus.

Perhaps the most noticeable peculiarity of high frequency currents is that they flow to an insulated conductor; that is, a complete circuit is not required as in ordinary cases. Thus, we start the machine in operation and hold near one terminal a piece of sheet metal suspended by a silk cord. The discharge passes to the metal plate although it is well insulated. In the same way if we connect the body with one terminal, the electricity is flowing through the connecting wire just as truly as though it were connected with the opposite side of the machine and a complete metallic circuit were formed. Let us see if we can find a reason for this.

If we place a person upon an insulated platform and connect him with one terminal of a static machine, or other source of direct current electricity, there is a momentary rush of current through the connecting wire to the body of the person under treatment. If the effects of leakage be neglected, this rush of current is only of very short duration and persists until the body of the person connected with the machine is charged to the same potential as the machine itself. If a continuous flow of current is desired more than one connecting wire must be used.

In the above mentioned case we assume a direct current was used. Let us see what takes place if a current of high frequency be

substituted, that is, connect the person under treatment with a high frequency apparatus exactly as was done in the case of the static machine. To make the two cases alike the insulated platform may be employed, although with high frequency currents this cumbersome device is entirely unnecessary.

With high frequency currents the result of our experiment is entirely different from the previous case. We have a condenser or capacity effect now which is the most important thing to be considered. The person corresponds to one coating of a Leyden jar, the space surrounding him is equivalent to the glass separating the coatings, and the walls of the room, or other surrounding objects, may be considered as the other coating. We have in effect, therefore, a condenser connected to one side of our high frequency apparatus. Now it is a fact that condensers allow high frequency currents to pass through them and the crude condenser formed as above described is no exception to the rule. Currents come from the machine along the connecting wire as conduction currents, and pass from the body of the person under treatment, into the surrounding space as the displacement currents of Maxwell. The currents flow through the body of the patient, therefore, although only one terminal of the machine is used.

By connecting a person with one terminal of the machine an electrostatic bath may be administered. Although he is being charged and discharged at an enormous rate, no sensory effect is produced. He does not know whether the current is on or off. An effective way to demonstrate the presence of the current in his body is to hold a vacuum tube near him while the current is on. The tube will glow brightly although a considerable space separates it from his charged body. Notice also that the tube glows with undiminished brightness whether it is held near his head or feet. Every part of his body is surrounded with an intense electrostatic field. This is one method of therapeutic treatment, special vacuum electrodes being used for the various cavities of the body.

If we take six ordinary sixteen candle power incandescent lamps connected to one terminal of the apparatus and to a metal electrode, to be held in the hand, we can pass enough current through a person to light all six of these lamps. The lamps burn brightly and yet no sensory effect is produced. This is a most valuable and peculiar property of high frequency currents, since a large quantity of energy may be used therapeutically with little or no inconvenience to the patient.

A rather striking experiment is the deflagration of metals by high frequency currents passing through the body of the experimenter.

Take a short piece of iron wire and hold it securely with pliers. Allow the high frequency discharge to pass to the wire and let us see the result. The large amount of energy passing is sufficient to melt the metal, the characteristic scintillations being visible as the molten globules drop upon the floor.

Another peculiar property of high frequency currents is their apparent dislike for a turn in their conductor. They do not object very seriously to flowing along approximately straight conductors, but great difficulty is apparent when they are forced to travel through looped conductors or through a coil of wire. This is due to the fact that the frequency is high and currents of high frequency find difficulty in flowing in paths of considerable inductance. Let us illustrate this point with an experiment.

Let us take a piece of common electric light wire coiled so as to form three loops or circles of wire. Connect with the two ends of this coil an incandescent lamp. On the ordinary street circuit this heavy copper wire would melt before enough current would flow through the lamp to light it. The path of least resistance is through the heavy copper wire and hence the current flows through it in preference to the path through the lamp, which is a path of comparatively high resistance. But in the case of high frequencies we have other factors than the relative resistance of the circuits to consider. Inductance, as well as resistance, must be taken into account when currents of high periodicity are employed. When the rate of vibration is as high as we are considering in these experiments inductance is by far the more important factor. Resistance is of little consequence. The combined effect of resistance and inductance is called impedance, and for this reason these experiments are illustrations of impedance phenomena.

Let us apply a powerful oscillatory current to the lamp and coil of wire previously mentioned and the lamp will burn despite the fact that it is practically short circuited by a heavy copper wire of low resistance. Part of the current prefers the path of high resistance through the lamp rather than the path of low resistance through the heavy copper wire.

A peculiarity of high frequency currents worthy of our attention is that they pass readily through what we call insulators. For instance, a plate of glass about ¼ inch thick, which would serve as an efficient insulator for currents of ordinary potentials and frequencies, when used with high frequency currents, might as well be of copper as far as its restraining action on the currents is concerned. Place it between the terminals of the machine and the discharge passes through it with little effort. Furthermore there is but slight tendency for the current to jump around the glass, even when the terminals are brought near the edge of the plate. They actually seem to prefer to go through the glass rather than around it.

To prove this effect is caused by the high frequency character of the current we can lower the periodicity by throwing the Frequency Changing Switch on the machine (F Fig. 2). At this lower frequency the current still passes through the glass to a certain extent but it has more of a tendency to jump around the glass than it did at the higher frequency. Where the current is a direct one, as in the static machine, it would jump around the glass in every case

before it would go through it, unless it was powerful enough to actually puncture the glass.

A vacuum electrode is simply a piece of glass tube sealed up at each end and exhausted to a white vacuum. The current jumps to it as if it were metal. The high frequency currents find little difficulty in passing through the wall of the tube to the conducting vacuum within.

It is this ability of high frequency currents to go through glass which makes a high frequency apparatus, producing a really high frequency current, very economical in the use of X-ray tubes. The current passes harmlessly through the walls of a tube instead of passing through it disruptively and puncturing it. This is true, however, only of coils generating very high frequency currents. Many high frequency coils which generate currents of comparatively low frequency, are destructive of tubes.

To illustrate the great power of this apparatus we can allow the discharge to actually melt its way through a solid glass plate. To do this it is only necessary to concentrate the current at one point. Place the glass plate between the main terminals of the machine and turn on the current. At first the discharge passes as before harmlessly through the insulation. It flows through as a displacement current of Maxwell, however, and not as an ordinary conduction current. These displacement currents, nevertheless, heat the material through which they pass just as conduction currents do, and this is what happens in the glass. It becomes rapidly heated, due to the immense amount of energy passing through such a small area. Now, when glass is heated its insulating qualities are impaired, that is, it becomes more or less of a conductor. When this takes place, the current finds it easier to pass through the glass plate as an ordinary conduction current, rather than as a displacement current. It passes disruptively instead of harmlessly through the glass, and in doing so punctures the glass. By slowly moving the plate when it is between the terminals we can cause the discharge to melt a path for itself, and in this manner melt any given design into the glass. By tapping the glass lightly or spilling a small quantity of water upon it during this operation, the glass breaks along the line the discharge passes. This is a rather novel way of cutting glass.

The property of currents of high frequency and potential to pass through insulators is utilized in a novel and very useful method of treatment. I refer to what is called the plate glass treatment.

In cases of indigestion and constipation the plate glass treatment is particularly efficacious. In administering this treatment the patient holds a piece of plate glass over the abdomen or other portion of the body to be treated, and the point electrode is then held a short distance from the surface of the glass. The discharge passes from the point to the glass and spreads out in purple streamers over a considerable area. The patient experiences practically no sensory effects during this treatment other than a slight warmth over the treated area.

With the extremely high frequencies we are considering the effects of electrostatic induction are marked. D'Arsonval utilized this fact by surrounding his patients with a solenoid of wire through which he passed currents of high periodicity. This procedure bathed the patient in a rapidly fluctuating electrostatic field which gave rise to powerful induced currents within the body of the person under treatment.

With the apparatus here illustrated it is not necessary to use the cumbersome solenoid of D'Arsonval. In its place may be used what I have termed an Electrostatic Ring. This is simply a few turns of heavily insulated copper wire wound into the form of a ring. To those who have used the bulky solenoid of D'Arsonval it is unnecessary to emphasize the advantages of this more compact form of coil.

At first thought it might be said that an inducing conductor of this form would only induce currents in the patient's body in the vicinity of the plane of the coil, but such is not the case. I have made experiments which would go to prove that by surrounding a patient with an inductor of the above description, powerful induced currents may be set up throughout the entire length of the body. We can demonstrate experimentally the intensity of the electrostatic field produced by this appliance.

Connect the Electrostatic Ring with a current on the machine called Heavy Current Oscillatory. This oscillatory current is of enormous amperage and when circulated in a coil of wire produces very powerful electrostatic effects.

Take another coil of wire similar to the coil connected to the machine, except that it has more turns of wire in its construction—in these experiments the coil connected with the machine is the primary winding and the other coil the secondary winding of a crude Tesla transformer, and connect an ordinary incandescent lamp with the secondary coil of this high frequency transformer and bring the coils into the electrostatic field produced by the primary ring. The lamp lights brightly although over a foot of space separates the two coils. The energy passes from the primary ring to the secondary as a rapidly varying electrostatic stress in the ether. We have, on a small scale, the transmission of power without wires.

In place of the lamp in the foregoing experiment let us use a small piece of iron wire, and the current heats the wire when the secondary ring is brought near the primary. When we place the secondary directly upon the primary the iron wire is melted.

In a previous experiment I referred to a rough model of an Oudin resonator. In this experiment the secondary coil or resonator part was connected at its lower end with the primary. Let us repeat this experiment but not connect the two coils together. Place a coil of fine wire on a piece of plate glass and attach the lower end of the wire to a metal handle held in the hand. As this wire coil is brought into the electrostatic field the discharge streams from the uppermost turns, although over a foot of space separates the coil of wire from the inducing ring. As we raise this portable secondary

out of the field of force the energy decreases, although the discharge is still perceptible when over three feet of space separates the two coils.

It has often been stated that high frequency currents were all well enough for therapeutic application but were not adapted as a generator of the X-ray. This opinion is generally held and is probably due to the fact that high frequency apparatus employing other than the Tesla principle is not suited to X-ray generation. The new type of Tesla apparatus, however, which has recently attained a high state of perfection and is distinctly an American production is a powerful producer of the Roentgen radiations, in fact is often to be desired over the induction coil and static machine. By employing a suitable form of tube X-rays may be obtained, using high frequency apparatus, which equal in definition those produced by a tube excited from either a coil or static machine. The rays generated are far more powerful than those which can be obtained with the ordinary static machine and compare favorably with those generated by an induction coil.

The mechanical simplicity of construction and operation of the high frequency apparatus should appeal to the medical profession, where, more than in any other profession, powerful and exact results are desired. In high frequency apparatus for the alternating current there is no revolving or movable part whatever. The current is taken directly from lighting mains and by a series of purely electrical transformations is raised to an enormous potential and periodicity. In this process no mechanical device, with its liability to get out of order, is employed. The great advantage of this is evident.

* * *

Wireless telegraphy depends for its success upon the propagation of Hertzian waves in the ether and Hertzian waves are in turn dependent upon high frequency currents for their production. Some time ago it occurred to me to use my apparatus as a transmitter in wireless telegraphy and the results were so satisfactory that we now issue instructions for repeating these experiments, as well as supplying the necessary accessories to those who do not care to construct them for themselves. To give an idea of the simplicity of the apparatus employed to demonstrate wireless telegraphy is the purpose of the following experiment. Fig. 4 is a diagrammatic view of the receiver. As will be seen it is of such a construction that anyone can make it at a slight expense. The simplicity of construction, however, is no criterion of efficiency of the device, as this receiver as shown is very sensitive and may be employed over considerable distance.

The apparatus shown in Fig. 2 is a transmitter par excellence, but we must construct a receiver to detect the electrical waves. A receiver may be constructed if the following articles are obtained: A common sewing needle, two pieces of carbon such as used in batteries or to replenish street lighting arc lamps, one dry battery and

an ordinary telephone receiver. Remarkable as it may seem, a very sensitive wireless telegraph receiver may be constructed from these simple materials.

File the two pieces of carbon so that each will possess a smooth, sharp edge at least an inch long. Get the edge as sharp as possible. Support these prepared carbons about an inch apart in such a manner that they are insulated from each other and have their sharp edges parallel and uppermost. Connect up the apparatus as shown in the cut.

Connect one of the main terminals of the high frequency apparatus we are to use as transmitter to the ground and the other to a vertical wire or antenna. The length of this wire will vary with the distance signals are to be transmitted. For a short distance a wire ten feet in height will be sufficient.

Provide a similar ground connection and aerial conductor for the receiving station as shown in the cut.

If it is only desired to transmit signals across one or two rooms, or from one part of the house to another, it is often not necessary to use the ground connection. In its place may be used a sheet of tin foil, a tin wash basin, or any other large metal object to serve as capacity.

To receive signals place the sewing needle across the two carbon knife edges and the receiver is ready. Turn the current on and off at the machine by means of the Auxiliary Control Switch. Every time the current is turned on at the transmitter a singing noise should be heard in the receiver and this noise should persist as long as the current is on.

Often when the receiver does not respond evenly its operation may be improved by shifting the position of the needle on the carbon knife edges. As mentioned before these edges should be as sharp as possible.

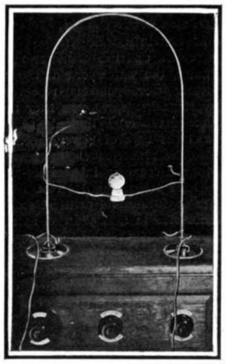
* * * *

In this paper I have selected only a few of the very many wonderful and intensely interesting experiments which may be performed with currents of high potential and great frequency. The field is so broad and the work so instructive and interesting, that one cannot start experimenting even in a small way, without discovering many new and peculiar properties of these currents. When we look back upon the past and consider the great strides which have been made and the therapeutic results accomplished with high frequency currents, who shall draw the boundary line for the expansion of the future?

HIGH-POTENTIAL DISCHARGES.

BY A. FREDERICK COLLINS.

The various manifestations of high-frequency and high-potential discharges offer a fertile field of research, especially for the amateur investigator, since it is a subject that has received comparatively little attention considering its significance as revealed in its recent applications to electrotherapy, radiography, and wireless telegraphy.



LIGHTING AN INCANDESCENT LAMP SHORT-CIRCUITED WITH HEAVY COPPER.

The current has the choice of two paths—an easy one through the copper bar and a path of higher resistance through the lamp—and it chooses the latter. Ordinary currents would take the easier path.

The term "electric discharge" is understood to include all modes of equalization of differences of potential between the terminals of a source of electrical energy on their connection by a conductor, by the removal of their charges by a stream of electrical particles of air, or by a sudden discharge that breaks down the air or other intervening dielectric. These are the three chief methods of restoring the electrical equilibrium, and are known respectively as the conductive, the connective, and the disruptive discharge.

The various forms may be further subdivided into alternating, arc, brush, brush and spray, dead-beat, flaming, glowing, lateral, oscillating, periodic, streaming, stratified, impulsive, and periodic discharges, and these may be produced by utilizing a source of direct or alternating current of low voltage, as for instance a commercial generator; a high-potential apparatus as an induction coil, or a high-potential, high-frequency arrangement, as a Tesla coil, depending upon the requirements of the various cases.

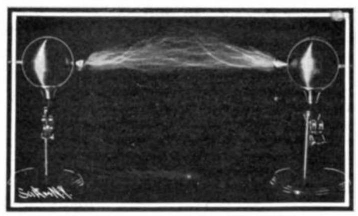
In this review we are concerned only with disruptive and connective discharges, the former in its application to wireless telegraphy and the latter in its relation to the human body. Since only potentials such as can be obtained with an ordinary induction coil are needed for disruptive discharges, these will be described first.

In the production of a discharge of this nature there are two diametrically opposite conditions involved, the first representing an oscillator and spark-gap in an unenergized and non-conductive state, and the second when it is energized and rendered highly conductive, thus completing the circuit. To bring about this result the arms of the oscillator are charged with high-potential energy impressed upon them, which is set up in the secondary of the coil in the form of currents. This kinetic energy is then converted into electrostatic energy, and when the static charge is maximum for a given resistance offered by the dielectric between the surfaces of the spark-gap electrodes heat is evolved in consequence, and when a certain critical temperature is reached the positive electrode volatilizes, and it is this effect that forms the initiative in breaking down the dielectric of the spark-gap.

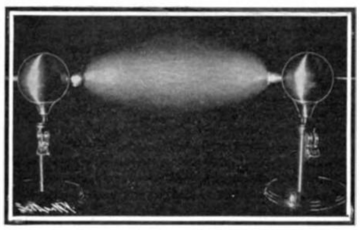
The law relating to the heat evolved states that it is proportional to the square of the charging current and to the resistance of the dielectric between the positive and negative electrodes forming the boundaries of the spark-gap. The energy that is emitted from the positive electrode is proportional to the potential difference impressed on the oscillator system and the specific inductive capacity, while it is inversely as the distance separating the spark-gap electrodes. The length of the spark that passes depends also largely on the following factors, namely, the difference of potential between them, the character of the medium that separates them, and on the density or pressure of the dielectric through which the discharge passes.

A decrease in the pressure of the medium serves to increase the distance through which a spark will pass, but a point is quickly reached wherein a further decrease has the effect of cutting down the length of the spark, and hence where a low vacuum will permit the passage of high-potential currents over longer distances than in air, a high vacuum retards them even though the potential may be considerably increased. Then again the metal of which the electrodes are made determines the sparking capacity to a certain appreciable extent since some retard and others assist the process of volatilization, and finally the size and shape of the spark-gap-electrodes also have their effect upon the discharges.

From these considerations it will be observed that when the electrodes are placed closely together the strength of the charging current is increased, and hence the heat developed causes the temperature to rise. When the sparking distance is greater than the maximum difference of potential can easily break down, a faintly luminous discharge will be seen issuing from the positive electrode, especially if it should present any sharp points. This phenomenon occurs in virtue of the fact that metallic points are more easily heated than those in the form of spheres.



HIGH-FREQUENCY ARC DISCHARGE.



HIGH-FREQUENCY STREAMING DISCHARGE.

When the charge and temperature reach a critical value a conducting microscopic thread of gaseous vapor is developed and this is attracted to the negative electrode, to which it passes by the path of the least resistance. When this filament bridges the gap its diameter is very greatly increased, the resistance that was previously enormously high becomes minimum, and the current surges forth and back until the energy of the system is damped out by the sum of the resistances.

While Tesla was not the first to produce the varied and beautiful forms of convective discharges he was probably the first to systematically investigate them. Though convective discharges may be frequently observed from a pointed positive electrode of an induction coil, they are much more intense and brilliant when the potential and frequency of the oscillations are stepped up by means of a secondary transformer.

The compact apparatus for obtaining high-frequency and high-potential discharges shown in the illustrations was designed by Prof. Ovington, who repeated many of Tesla's experiments and introduced several new ones during the recent electrical exhibition at the Madison Square Garden.

With high potentials and high frequencies the electrostatic field is collapsed more easily than when those of lower value are reached, while the oscillations increase the temperature developed by the transition of static into kinetic energy and for this reason the volume of vapor is increased and an arc discharge results.

The flaming and streaming discharges which are forms of the connective discharge are closely allied and occur when the frequency and potential is increased beyond a certain value; under these conditions the discharge assumes definite characteristics wholly different from those of the disruptive discharge. In these



BURNING PLATINUM WIRE WITH CURRENTS PASSING THROUGH THE BODY.

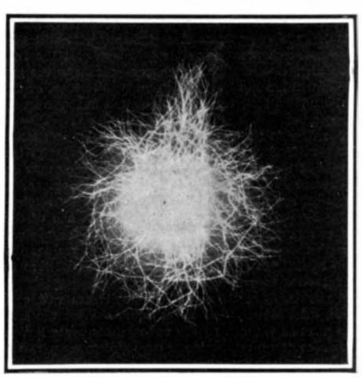
A platinum wire is held in the fingers and near one terminal of the machine. The spark jumps to the body and through the wire.

forms of discharge the energy passes between the electrodes as luminous streams. Such discharges obtained with high-frequency coils are different from those obtained with electrostatic machines, as they lack in the violet color developed by the positive static electrode as well as the bright glow of the negative electrode.

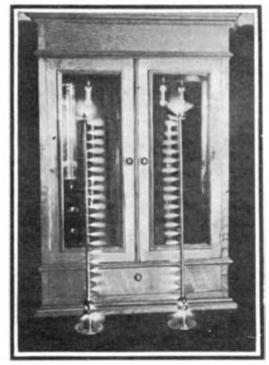
When the frequency and potential necessary to produce the flaming and streaming discharges is increased new phenomena result and a brush and spray discharge is obtained. With suitable electrodes comprising a large number of small points the emanations resemble jets from a gas-flame escaping under high pressure. According to Tesla "they not only resemble but they are veritable flames, for they are hot. Certainly they are not as hot as a flame of gas, but they would be so if the frequency and potential would be sufficiently high."

If the frequency and potential is further increased, the discharge will pass through several inches of solid glass. Ordinarily glass is an insulator of electricity, and yet in this case the streams flow through it apparently with the greatest freedom. The flow of luminous energy has a tendency to stream out and to be dissipated to such an extent that when the brush is produced at the positive electrode no disruptive discharges will occur, even though the hand or any conducting object is held within the stream, and what is even more singular, the luminous stream is not at all easily deflected from its path by the approach of a conducting body.

Under these remarkable conditions the energy loses its property of producing sensation when it comes in contact with or passes through the human body, and a person may now be connected with the source of high-potential and high-frequency currents and be completely charged, though he will feel nothing; that he is a portion of an oscillator, however, can be readily determined, for if a vacuum tube is brought near any part of his body it will glow due to the electric waves emanating from him. To illustrate how absolutely devoid the sensory nerves are to these currents, a



THE AUTOGRAPH OF AN ELECTRIC SPARK, WRITTEN ON A PHOTOGRAPHIC PLATE.



ELECTRIC TESTS.

The current issues at an enormous voltage from a large number of small points, so that it seems like jets of burning gas escaping at high pressure.

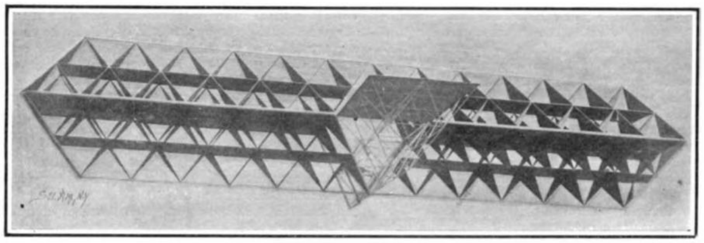
vacuum tube may be held in the mouth, and a current passed through the lamp lights it and then continues on its course, passing through the membranes of the mouth, which are perhaps the most sensitive of any in the body, yet no sensation whatever is experienced. A half-dozen incandescent lamps may be lighted with current passing through the body and no sensation is felt although instant death would result were the rate of oscillation reduced within certain limits.

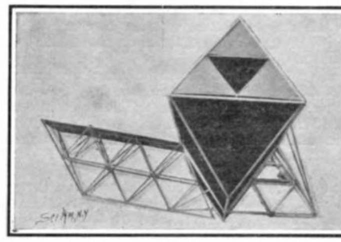
To show the impedance a copper bar of large diameter offers to a high-frequency current, an incandescent lamp is short-circuited across the former and the current is thus given the choice of two paths, an apparently easy one of small ohmic resistance and high impedance through the copper rod, or a seemingly more difficult one of large ohmic resistance and low impedance through the lamp. While an ordinary current would of course choose the former, the extraordinary current traverses the latter path.

The practical application of these discharges is found in radiotherapy. Their use is being extended more and more, and by many it is considered a rational method in therapeutic practice. Heat, light, and electricity when properly applied have accomplished surprising results. With the apparatus shown not only are all the various remedial manipulations of electricity available, but current is also supplied suitable for producing the X-rays, ultra-violet light, etc.

THE AERO CLUB OF AMERICA'S EXHIBIT OF AERONAUTICAL APPARATUS.

A most interesting exhibit, in connection with the Sixth Annual Automobile Show held recently in the 69th Regiment Armory, was that made by the newly-formed Aero Club of America. This exhibit was the most complete of its kind ever held in any part of the world, for all types of flying machines, balloons, and airships were represented. In the same room with Santos-Dumont's No. 9 airship was to be seen one of the original gliding machines of Herr Otto Lilienthal, as well as the gasoline and steam-propelled aerodromes of Prof. Langley and the motor-driven aeroplane models of Herring and Hargrave. Other apparatus shown consisted of Prof. Bell's tetrahedral kite, Ludlow's combined box kite and aeroplane, Myer's electrical torpedo, and Kimball's heliocoptere. The original Hargrave box kite was also shown, as well as numerous models designed by Herring and Chanute. Besides these very complete exhibits of apparatus, the walls of the room were covered with a large collection of photographs showing the machines of other inventors, such as Whitehead, Berliner, and Santos-Dumont; and other photographs showing airships and balloons in flight, together with bird's-eye views taken from the same. In another room cinematograph exhibitions were given twice every day. The views shown consisted of motion pictures of the Vanderbilt automobile race, the Mount Washington hill climb, balloon ascensions, and experiments in raising aeroplanes when towing them by means of a motor boat. In showcases placed in the exhibition hall were seen primitive models of flying machines from the Patent Office at Washington, light motors and other appliances for aeronautical work, together with a collection of books bearing on the subject. Among the exhibits of apparatus of historic interest were the large wood propellers which Mr. Her-

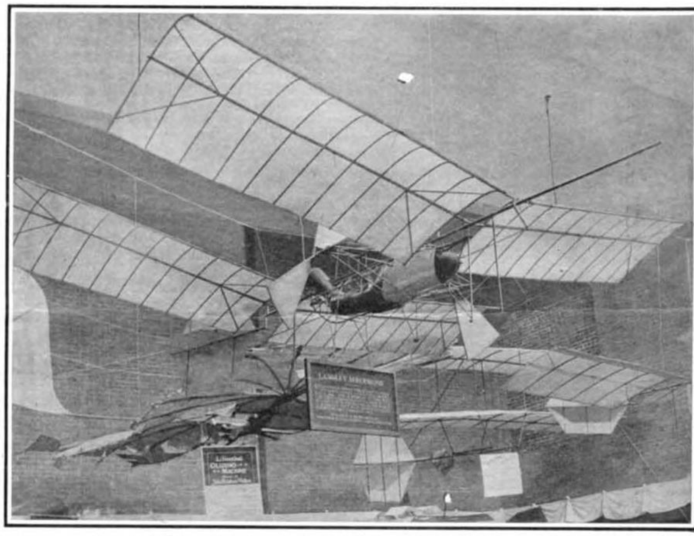




Side and End Views of Prof. Bell's Tetrahedral Kite, Which, When It is Released in Mid-Air, Descends in a Series of Curves, and Sometimes Describes a Complete Circle Like a Soaring Bird.

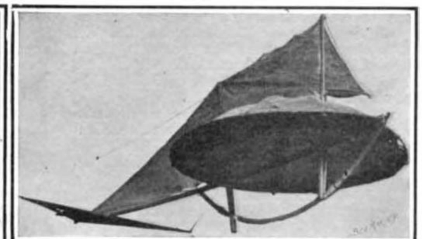
This photograph shows the rear of kite, which is made up of tetrahedral cells constructed of spruce sticks 4 mm. (0.157 inch) square and 25 cm. (9.842 inches) long, bound together with fine twine and covered with red silk. The weight of a single cell is 9½ grms., or ⅓ of an ounce.

This view shows the tail tipped upward, which is accomplished automatically by a pendulum in the bow when the kite makes a dive.



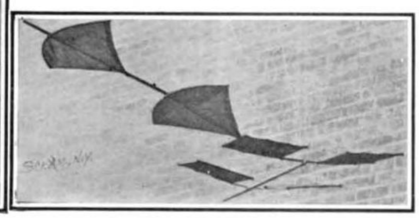
Langley's Steam Aerodrome—the First Power-Driven Aeroplane to Fly.

The first successful flight of this machine was at Quantico, Va., on May 6, 1896. The rudder at the left of this picture forms part of Lilienthal's gliding machine. In the right-hand corner of the room is seen the Herring-Arnot two-surface aeroplane which has been used successfully by Mr. Herring and the Wright brothers.



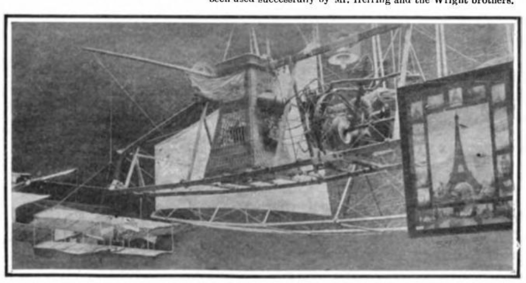
Herring's Dome Kite of 1896.

With this kite the center of pressure is almost constant with widely varying angles of inclination. Its lifting power is also high.



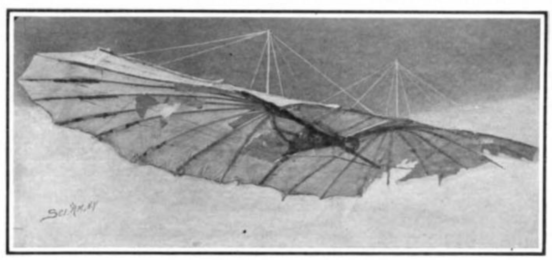
Samples of Brown's Bi-Planes.

This type of aeroplane consisting of two following surfaces was invented about 1878. Langley's aerodrome was built on this plan. But 20 pounds per horse power can be lifted with this type of machine where from 100 to 150 pounds per horse power can be lifted with the superposed plane type.



The Motor and Basket of Santos-Dumont's No. 9 Airship.

A blower is arranged to blow on the motor cylinders to cool them properly. A large bicycle wheel acts as a flywheel and the shaft carrying the propeller runs forward to the front of the framework. The model two-surface aeroplane in left-hand corner is a motor-driven model which is said to have made numerous successful free flights.



One of the Original Lilienthal Gliding Machines with Which He Made Hundreds of Successful Flights.

This machine has a rudder, which is shown in the view of Langley's aerodrome. Lilienthal succeeded in steering in a sharp curve to right or left with this machine.

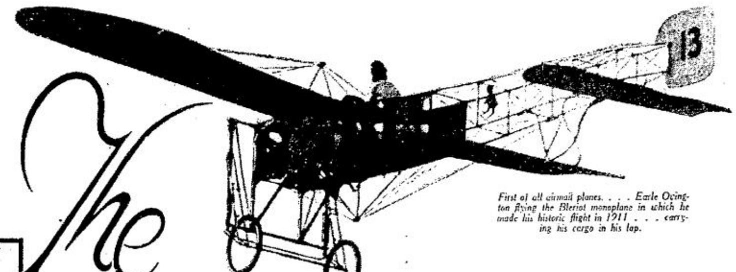
INTERESTING EXHIBITS AT THE AERO CLUB'S EXHIBITION.



USING THE HUMAN BODY FOR SENDING A WIRELESS MESSAGE BY THE DE FOREST SYSTEM WITH THE ASSISTANCE OF DR. OVINGTON'S MACHINE. IN THIS EXPERIMENT 200,000 VOLTS OF HIGH FREQUENCY CURRENT ARE PASSED THROUGH THE HUMAN BODY, WHICH SERVES AS A MAST.

Uncle Sam's far-flung airmail system now begins its 21st year and this is the little-known story of Earle Ovington, who piloted the first mail plane in 1911, and is still flying

The Airmail Comes of Age



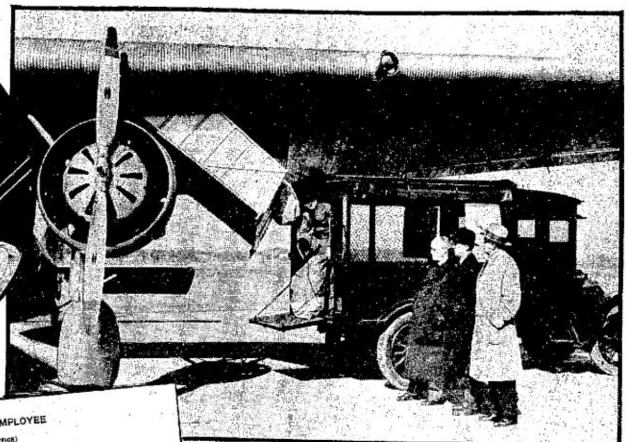
First of all airmail planes. . . . Earle Ovington flying the Bleriot monoplane in which he made his historic flight in 1911 . . . carrying his cargo in his lap.



The first bag of airmail goes aloft. . . . This historic picture, taken in 1911, shows Postmaster General Frank H. Hitchcock handing to Pilot Earle Ovington the first sack of mail ever carried by plane.



Ovington's mascot on the first air mail flight. . . . A toy French policeman, "Frieze," which perched in the plane's framework.



The progress of 20 years. . . . A modern tri-motor airmail plane being loaded in wing compartments at Bolling Field, Washington . . . so that the pilot no longer has to carry the mail in his lap.

By ISRAEL KLEIN

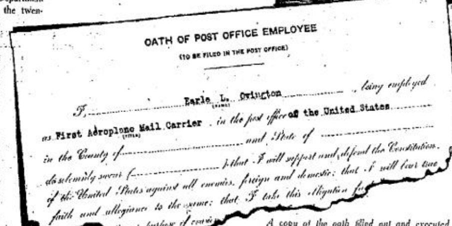
IT'S a daily grind now, flying the airmail.

Some 300 bored pilots are doing it today, speeding in several directions across the country, day and night, over 24 routes, carrying thousands of pounds of Uncle Sam's mail as unassumingly as though they were working on a rural free delivery route.

Each day thousands of letters and packages, carrying the special long airmail stamps, are being posted throughout the country with the same degree of indifference with which any ordinary mail is being dispatched.

The other day, the Post Office Department celebrated, with special ceremonies, the twentieth anniversary of the first airmail flight. It was a stirring and memorable event—to those who understood its significance. But at the time this was going on, more airmail letters were being dispatched and pilots took the air just as nonchalantly as they had been doing day after day.

Yet that first airmail delivery, on September 23, 1911, is a historic event in the annals of the United States Post Office Department. It marked not only the first attempt on the part of this country to make use of the airplane for speedier delivery of mail, but, even more important, it was the first move on the part of the United States to encourage aviation in other than a military way.



OATH OF POST OFFICE EMPLOYEE

(TO BE FILED IN THE POST OFFICE)

I, Earle L. Ovington (name), being employed as First Aeroplane Mail Carrier (title) in the post office of the United States in the County of .... and State of .... do solemnly swear (............) that I will support and defend the Constitution of the United States against all enemies, foreign and domestic: that I will bear true faith and allegiance to the same: that I take this obligation fr[eely] ... purpose of evasion ...

A copy of the oath filled out and executed by Ovington in 1911 before he made the first airmail flight.

Comparatively recent as this event was, it was a bold and crazy venture. Frank H. Hitchcock was postmaster general at the time. A 10-day "international" aviation meet was in progress in an "aerodrome" on Long Island. Timothy L. Woodruff, Lieutenant Governor of New York, lent an official atmosphere to the occasion by his daily appearances. He was the pioneer airport manager and airmeet director.

On the field, George Beatty, one of the first aviators in the country, was warming up his white-winged Wright biplane. Not far from him were Captain Tom Baldwin and his "Red Devil," Tom Sopwith and his great, gray "family bus," and Earle Ovington, with his cream-colored Bleriot monoplane.

IT was a colorful and curious flock of flying machines. The most daring pilot today would hardly think of taking the air with one of these. For they were slim, scraggly structures compared with the machines of today.

Yet here was the start of the American airmail, of modern commercial aviation.

Into this group came a telegram from Postmaster General Hitchcock to Lieutenant Governor Woodruff. It was a proposal to carry a sack of mail to Mineola, L. I., hardly 10 miles away, not just as a lark or experiment, but as proof of Hitchcock's conviction that the flying machine could turn out a most efficient and speedy form of mail carrier.

Earle Ovington got the job. He became the first airmail pilot in the United States.

Today, Ovington, gray-haired, partially bald and nearly 52, still flies, but the ship he takes up is quite a contrast to the one he flew on that first airmail delivery.

"I brought that Bleriot over from France," Ovington recalls. "It had a 70-horsepower Gnome motor, a French 7-cylinder radial engine cut out of a solid steel block. Its curved wings were interchangeable with a set of flat wings with which I could make faster time than Bleriot himself behind a much more powerful motor.

"The open framework of the airplanes of that day made them quite difficult to manage. We had to hold on to our sticks at all times, for the least suggestion of a side-slip would almost be the end of us. We couldn't stop a side-slip unless we kicked the rudder over and dove right into the direction of the slip. It was something like tight rope walking on the invisible air currents."

DIFFICULT as managing the airplane of those days was, it became much more of a stunt with extra baggage of any kind along. For there was no room in Ovington's plane for anything besides himself. Hitchcock came down to Long Island during the meet, with the intention of accompanying Ovington on his airmail flight. But he had to content himself with flying another day with Captain Paul Beck in an army Curtiss biplane.

In fact, Ovington had difficulty even carrying the mail. He had to get in first, and the sack of mail had to rest on his lap—the only place he could put it.

There were 640 letters and 1280 postcards in that sack. Regular mail postage was enough to carry each piece, but a special cancellation stamp was used and a new cachet, or rubber stamp, also applied. Now, one of these pieces of mail, stamped "Aerial Mail Station No. 1" and "Aerial Special Dispatch," and dated September 23, 1911, is the envy of "first flight" collectors. With Ovington's signature one is worth $60, and without it one of these envelopes will bring $30.

"It was difficult enough handling that plane without an encumbrance," Ovington says. "The Bleriot had no vertical stabilizers and no ailerons. This meant that we were just rudder flyers in those days. In place of aileron control, we had an arrangement of wires from the stick to the ends of the wings on each side, so that we had to 'warp' the wings to bank.

"On my machine, the apparatus in front of me was a cumbersome 'cloche' or bell-shaped device on the stick, to which wires to each wing were connected. I had to keep both my hands on this stick at all times, working it like a sensitive stabilizer to keep the plane level. With that sack of mail on my lap, that was no easy task."

But Ovington made that first trip without a mishap, and he continued to fly the mail daily during that meet. He had been sworn in by Governor Woodruff as the first airmail pilot and he was the only civilian for the job during the week.

SINCE that first flight Ovington has made flying his hobby. He has owned 12 airplanes in the last two decades, and his thirteenth today is a fast ship of his own construction.

An electrical engineer by profession, he gets more enjoyment out of flying the mail once every three weeks over an unofficial route from Santa Barbara, Calif., his home town, to Santa Cruz Island, about 30 miles off shore. He makes the flight in his land plane, although he carries a rubber boat, oars and a canteen of fresh water for safety.

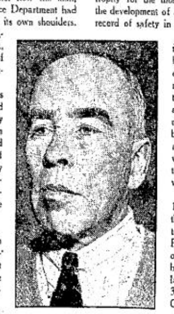
Outside of this and his historic trip, Ovington has never flown the airmail!

He's a transport pilot, too, but he hasn't flown a passenger, either!

He has a boy and a girl, one nearly 20, the other 18, but he won't let them solo until after their college days!

When Earle Ovington first flew the mail, 20 years ago, the Post Office Department had to take that responsibility on its own shoulders. Ovington carried nearly 50,000 pieces of mail that week, all at the regular rate of postage, all at quite an expense to Uncle Sam.

Today, some 300 pilots are carrying airmail day and night over a total of nearly 24,000 miles of air routes, in more than a thousand round trips each month. Three of these routes cross the country from the Atlantic to the Pacific, and one of these cross-country flights is made in the record time of 36 hours.



Pioneer of the airmail routes. . . . Earle Ovington, who still makes flying his hobby.

THE rise of the airmail in this short time is a remarkable adventure. For it has been only in the last five years that growth of any consequence could be observed.

For six years after Ovington's first flight, the Post Office Department had to use funds originally set aside for other purposes in its encouragement of airmail flying. During that time it built up a route between Boston and New York, between Washington and New York, and other cities, all under its own operation.

Early in 1917, Congress appropriated $100,000 for airmail development. The World War, however, distracted all attention from this development and so it wasn't until after the Armistice that Uncle Sam opened his eyes.

IN those days, flyers had quite a problem to get their planes over the Alleghenies, the Rockies or the Cascades, without crashing blindly into a hillside. They had no beacon lights at night, or radio signals to guide them through the fog. Detailed weather reports were sadly lacking.

Yet so well was the work done, and with so remarkably little loss of life, that in 1922 the airmail service was awarded the Collier trophy for the most important contribution to the development of aviation, with its remarkable record of safety in the air lanes.

The next year, night flying came along. The stretch between Chicago and Cheyenne, where formerly the mail had to be transferred to trains, was equipped with airway beacons, powerful, revolving land lighthouses by which pilots even today are guided. For that development, and its success, the airmail service again won the Collier trophy.

It is only since February, 1926, that the job of flying the mails has been let out to commercial concerns. In February, 1926, 328 miles of airmail flying were done by contract. Five months later, this had grown to 3597 miles, and the Post Office Department had spent nearly $90,000 for the purpose.

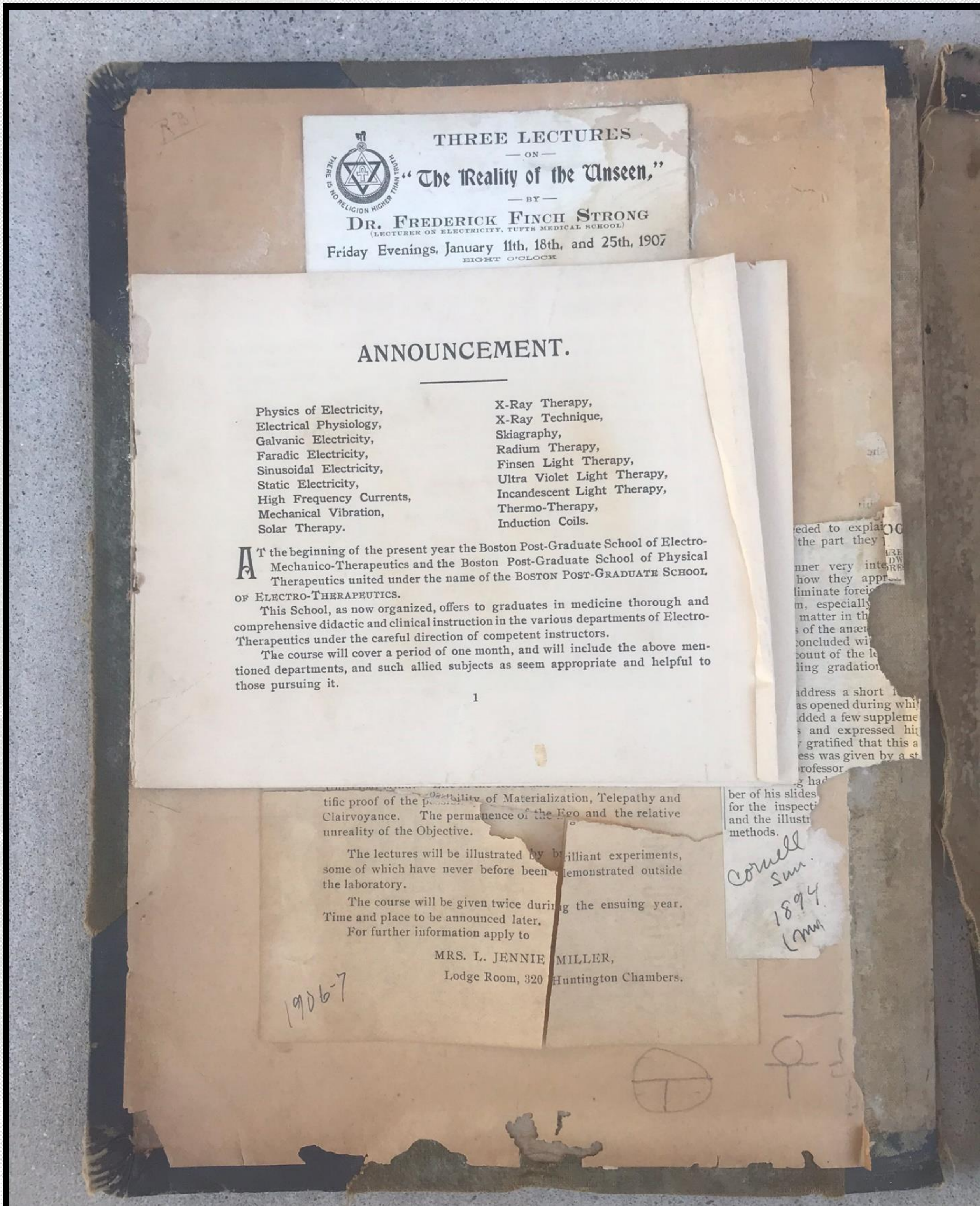
Airmail, however, should not be regarded as a venture unique to the United States. It is fast spreading all over the world, through South America, Australia, Europe, Asia, Africa. Even today, a pilot and his radio operator and navigator are trying to establish an All-American airmail route across the Arctic to Copenhagen.

Mail planes are flying daily between London and various important centers of Europe, even to Asia and Africa. And the mail is continually being speeded up.

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Earle Ovington and his wife Adelaide



THREE LECTURES

— ON —

"The Reality of the Unseen,"

— BY —

DR. FREDERICK FINCH STRONG

(LECTURER ON ELECTRICITY, TUFTS MEDICAL SCHOOL)

Friday Evenings, January 11th, 18th, and 25th, 1907

EIGHT O'CLOCK

ANNOUNCEMENT.

Physics of Electricity,
Electrical Physiology,
Galvanic Electricity,
Faradic Electricity,
Sinusoidal Electricity,
Static Electricity,
High Frequency Currents,
Mechanical Vibration,
Solar Therapy.

X-Ray Therapy,
X-Ray Technique,
Skiagraphy,
Radium Therapy,
Finsen Light Therapy,
Ultra Violet Light Therapy,
Incandescent Light Therapy,
Thermo-Therapy,
Induction Coils.

At the beginning of the present year the Boston Post-Graduate School of Electro-Mechanico-Therapeutics and the Boston Post-Graduate School of Physical Therapeutics united under the name of the Boston Post-Graduate School of Electro-Therapeutics.

This School, as now organized, offers to graduates in medicine thorough and comprehensive didactic and clinical instruction in the various departments of Electro-Therapeutics under the careful direction of competent instructors.

The course will cover a period of one month, and will include the above mentioned departments, and such allied subjects as seem appropriate and helpful to those pursuing it.

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tific proof of the possibility of Materialization, Telepathy and Clairvoyance. The permanence of the Ego and the relative unreality of the Objective.

The lectures will be illustrated by brilliant experiments, some of which have never before been demonstrated outside the laboratory.

The course will be given twice during the ensuing year. Time and place to be announced later.

For further information apply to

MRS. L. JENNIE MILLER,
Lodge Room, 320 Huntington Chambers.

1906-7

Cornell Sum. 1894

The following pages are excerpts from a large scrapbook on Frederick Finch Strong's life, compiled by him and his wife Ethel.

Electricity and Life

By FREDERICK FINCH STRONG, M.D.
Lecturer on Electro-therapeutics, Tufts Medical School, Boston

SCIENTIFIC progress during the past three decades has perhaps surpast that of all preceding ages; but we are still in the kindergarten class when we compare what is known with that which is still to be discovered. To *discover* means practically the same as to *uncover*, implying that the truth or fact was there all the time but was hidden, covered, occluded, or *occult;* and is it not a fact that many of the electrical discoveries of to-day would have been regarded as *supernatural* or *occult* by the scientists of a few generations ago? Of course there is nothing supernatural in the strict sense of the term, but many things remain *occult,* altho science is daily uncovering new and hitherto undreamed-of marvels.

There exist great *Cosmic Forces* of which we still know but little. Gravitation is one of these; we know something of its laws and the results of its action, but nothing whatever of its real nature. Electricity is another; of this we know somewhat more, and we now recognize it in a variety of forms, as light, heat, chemical action, magnetism, etc., but its *true nature* is still a deep mystery. *Life-force* or *vital energy* is another great Cosmic Principle; thru its action electrons are formed into atoms, atoms into molecules, molecules into crystals and chemical compounds, and these into the bodies of plants, animals and of man. We have no name for this force, but thru its action the great Cosmic Schei of Evolution goes on. In India they call it by a Sanscrit name—*Prana.* Here in the Occident we have not yet officially recognized this force; it is quite unorthodox to even suggest that it exists—simply because we have not been able to measure and record it by our still comparatively crude laboratory instruments.



Demonstrating in a Startling Manner, the Appearance of the Human (the Author's) Body When Charged With a High Frequency Current. This Picture Shows Exactly How a Person Charged From a Powerful High Frequency Apparatus Would Appear to Our Unaided Eyes, Were They Attuned to Respond to Vibrations of One or Two Millions Per Second, Instead of From 380 to 760 Million-Millions Per Second (the Range of Normal Human Vision). This Display Greatly Resembles the Natural Aura Surrounding the Human Body, but which Average Persons Can See Only by Gazing Thru Special Chemical Screens.

A few years ago, when almost every scientist was a materialist, we believed in nothing but matter and force; to-day science recognizes the necessity of a third basic principle, *Intelligence* or *Mind;* without this we can satisfactorily account for none of the facts of the world in which we find ourselves. Its manifestations in matter thru the Cosmic Forces give us at least a working hypothesis of life.



Electrical Autograph of the Human Hand, Showing the Radiations from it When Charged with a Powerful High Frequency Current.

As electricity has been the great field for the investigations of the past century so will the nature and manifestation of the *Life-force* be the source of the discoveries of the future. Even to-day we may hazard a few statements regarding this hypothetical *Prana* or *Vital-force*. For example, it comes to us—like all other active forces—from the Sun. It is stored and transmitted by plants and by the oxygen of the air, and in the human body it appears to be distributed thru the great Sympathetic Nervous System to every organ and tissue of the body. The Sympathetic nerves radiate from the Solar Plexus—our *Sun-center*. If bacteria or poisons interfere with this circulation, as for example in *infantile paralysis,* the muscles from which the supply of life force is cut off, lose their power of reaction and wither away. It is in this connection that we may study the action of certain electric currents as applied to the treatment of disease. It would seem that certain types of alternating currents of high frequency and voltage greatly facilitate the distribution of this vital principle (Nerve-force, Prana, or whatever you choose to call it), and this explains the action of one of the most valuable of recent medical discoveries.

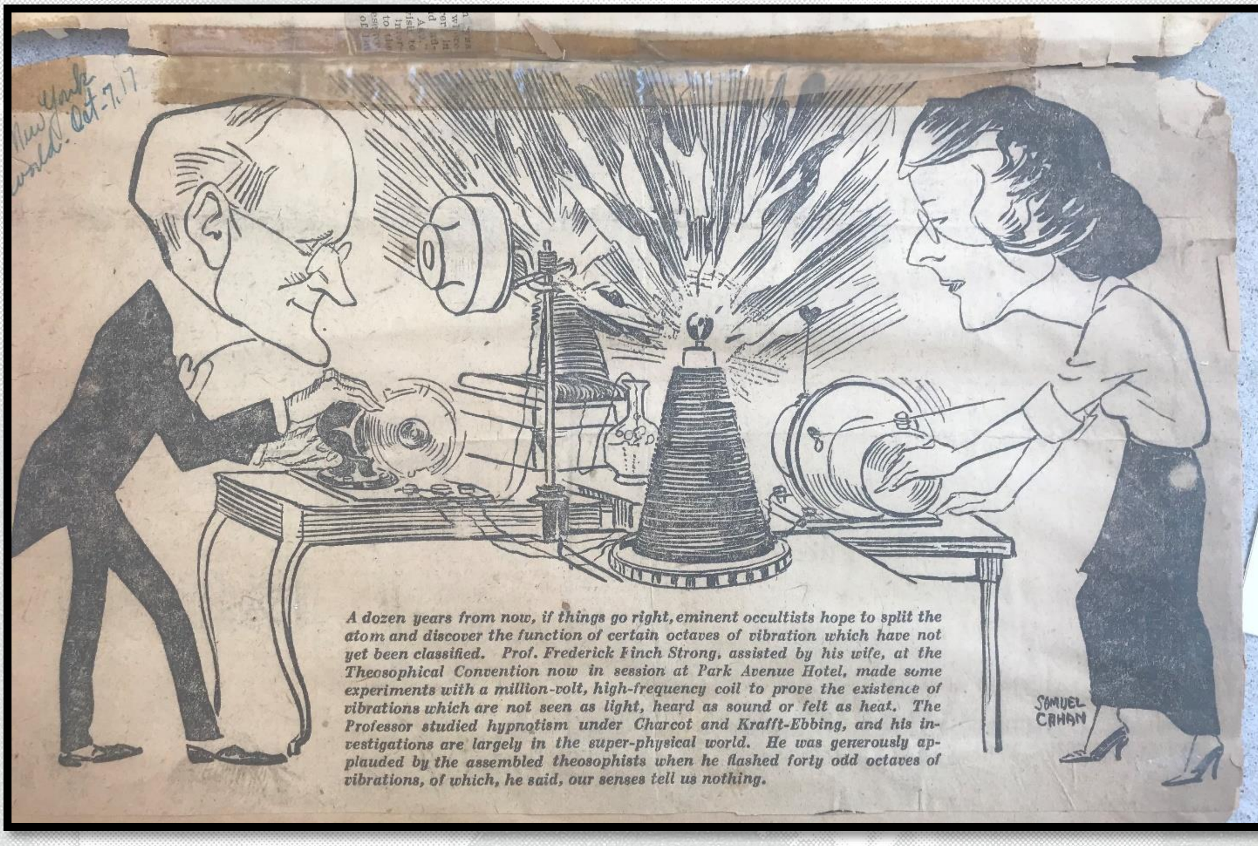
In 1893, Dr. Nikola Tesla described in a magazine article the remarkable effects upon himself and his assistants resulting from their exposure to the action of alternating currents of exceedingly high-voltage and frequency during some research work. He prophesied that when electrical oscillations were fully understood and applied by physicians that a *universal healing agent* would have been obtained—one which would so increase the vital energy and resistive reaction of the human body as to enable it to throw off all disease. The present writer, acting on this hint, constructed a high-frequency apparatus, tested it on a number of patients and reported his results to a local medical society in 1895. So far as can be learned this was the first clinical work ever done with the Tesla Current, altho d'Arsonval in Paris was then experimenting with his relatively low voltage currents, produced from 3,000 cycle alternators. Later, Apostoli, Denoyes, and others reported remarkable results from the currents induced in the bodies of patients placed inside of huge solenoids or wire coils thru which high frequency currents were passing. The effects obtained were: increase of strength, appetite and weight, induction of natural restful sleep, and increase in tissue combustion and elimination.

Early in 1895 the author devised the first *Vacuum electrodes* for applying Tesla currents to the patient. To-day thousands of physicians are using this device, often *mis*calling it the Violet-ray Treatment. This is of course a misnomer, the violet light in the tube having nothing whatever to do with the healing effect produced by the transmitted electrical oscillations.



A Striking Electrical Autograph of the Tips of the Four Fingers and Thumb of the Author's Left Hand. A High Frequency Current Charged the Hand while It Rested on a Photograph Plate, With the Results Shown.

(*Continued on page 831*)



A dozen years from now, if things go right, eminent occultists hope to split the atom and discover the function of certain octaves of vibration which have not yet been classified. Prof. Frederick Finch Strong, assisted by his wife, at the Theosophical Convention now in session at Park Avenue Hotel, made some experiments with a million-volt, high-frequency coil to prove the existence of vibrations which are not seen as light, heard as sound or felt as heat. The Professor studied hypnotism under Charcot and Krafft-Ebbing, and his investigations are largely in the super-physical world. He was generously applauded by the assembled theosophists when he flashed forty odd octaves of vibrations, of which, he said, our senses tell us nothing.



[...]NG LECTURES

"Force and Matter in the Unseen" is Subject Before Theosophical Society

"Force and matter in the unseen" was the topic of the first of a series of three lectures by Dr Frederick Finch Strong of Tufts medical college in Odd Fellows' hall last night, held under the auspices of the Theosophical society of Springfield.

Dr Strong, with complete and extensive electrical apparatus, showed how far our present laboratory science has carried us into the realms beyond the senses. He laid particular stress on the subject of electrical vibration, what occult effect it had on life, and what its intrinsic value was. By means of various low and high frequency transformers and resonators, fluorescent tubes and other apparatus, Dr Strong demonstrated the existence of some 46 octaves of vibration of which our senses tell us nothing.

Several startling experiments were performed by means of the Tesla transformer, producing a high voltage low ampereage vibration. Many gasps of wonder were heard when the scientist received 100,000 volts into his body without seemingly feeling an effect. Illustrations of the violet ray, introduced into the medical profession 22 years ago by Dr Strong, were shown and explained. Perhaps the most remarkable experiment performed was that of a million volt high frequency resonator in action, which discharged great branches of vibratory energy into the air.

The second of Dr Strong's lectures will be given to-night in Odd Fellows' hall, at which the subject will be "Life and intelligence in the unseen." Dr Strong will consider the phenomena of Spiritualism from the standpoint of physical and occult science.

Springfield Union –

[...]ING. MARCH 31. 1917

LISTS MARCONI AS SPIRIT HUNTER

Greatest Scientists Probing Unseen World, Says Theosophical Lecturer.

The second lecture of the series by Dr. Frederick Finch Strong was given in Odd Fellows' Hall last night. The main idea of the second lecture was to prove the existence of life beyond our knowledge. Actual proof of spirits will be so clearly defined in the near future, it was declared by Dr. Finch, that even the most skeptical will be convinced.

Impressions of the spirit world, he said, can be obtained now with the aid of the Roentgen Ray and a fluorescent screen, but science is working on a screen that will receive impressions even stronger than it is at present possible to obtain. Dr. Finch stated that the greatest of scientists are now striving to prove the existence of an astral body which may be made to communicate with people of the world as we know it. Among the names of the scientists whom he mentions as engaged in this work are Sir Oliver Lodge and Marconi.

"I never heard of a scientist who set out to investigate the spiritualistic world who was not a sceptic at the start," the speaker said, "and, furthermore, I was a materialist and an agnostic for 10 years, although my father was a Presbyterian minister." Also he stated that there had been no scientist who had made a thorough investigation who had not been convinced of a spirit population.



MAKES ELECTRICITY DO QUEER STUNTS

Springfield Union

Dr. Strong Opens Series of Lectures to Theosophical Society.

March 30. 17

An interesting lecture on electrical effects on occultism was given by Dr. Frederick Finch Strong, under the auspices of the Springfield Theosophical Society in Odd Fellows' Hall last night. The well known vaudeville act in which electricity is passed through the body and made to light incandescent lamps and fill glass tubes with multi-colored fire was shown, and many other interesting experiments were tried.

The experiments were conducted on a scientific basis and aimed to show the extent to which laboratory research has penetrated into the realms unperceived by the human senses. Dr. Strong stated that beyond the four known properties of matter—solids, liquids, gases and ethers—were four grades of still finer matter, existing between the atom and the electron, discovered by the use of instruments far more sensitive than any laboratory test-tubes or retorts that had been invented, re-leasing forces of such subtle character that only by the light of electrical waves could we determine their existence, or by their effects upon the human body. The electrical lectures continue tonight and tomorrow night in Odd Fellows' Hall, with further experiments.

REALMS BEYOND SENSES

Second Lecture by Prof F. F. Strong Under Auspices of Theosophical Society

More startling and mystifying statements were made by Dr Frederick Finch Strong of Tufts college last night in the second of his series of lectures on "The realms beyond the senses," under the auspices of the Theosophical society of Springfield. Dr Strong's topic last evening was "Life and intelligence in the unseen."

Experiments with the ultra-violet ray were shown, as laboratory proof of the lecturer's theory of the existence of forces and matter beyond earthly senses. Dr Strong said that eminent scientists admitted that there had been much investigation to show that "there is no death"; that the so-called dead live on an astral plane, and that there is a means of communicating with their souls. Sir William Crooks and Sir Oliver Lodge were mentioned as scientists who believed in spiritualistic phenomena. "There is no such thing as death," declared Dr Strong. "Death as we know it is merely the release of a soul from its physical shell." There was more than one incredulous expression when the scientist mentioned incidentally that there was doubtless a crowd of witnesses at the lecture from the astral world. These, he admitted, we could not see or sense, but this was because our minds were not trained in this particular respect.

Dr Strong is to give the third of his series to-night in Odd Fellows' hall, when he will speak on "The science of the new age," which will conclude with an imaginary visit to a scientific laboratory of the future.



PROBING REALM OF THE UNSEEN

Dr. F. F. Strong of Tufts to Lecture on Powerful Invisible Forces.

Dr. Frederick Finch Strong, for eight years lecturer on electro-therapeutics at Tufts Medical College, Boston, will give a series of three unusual lectures on electricity in Odd Fellows' Hall, Pynchon Street, next Thursday, Friday and Saturday evenings.

Dr. Strong is recognized as one of the leading electrical authorities of the country, and his experiments are being followed with keen interest by scientific men, as well as by the public, to whom the subject of electricity is always an absorbing one. Dr. Strong's father, the Rev. T. C. Strong, was president of Wells College. His mother was a sister of Francis Miles Finch, the author of the famous Civil war poem, "The Blue and the Gray." Dr. Strong was a student of Cornell, of Boston University and the University of Berlin. He brings to Springfield his latest electrical apparatus, including his million-volt high-frequency coil.

The first lecture, "Force and Matter in the Unseen" will show the extent to which present-day laboratory science has carried humanity into the realm beyond the senses. Although science has succeeded in harnessing the weird force we know as electricity and making it the servant of man, and although everyone has grown so accustomed to it that life would seem queer without its daily use, yet nobody knows what electricity really is, where it comes from, nor where it goes.

Dr. Strong, in this initial lecture, will show by electrical experiments the existence of 46 octaves of vibrations beyond the reach of our normal optic nerves, and of which our senses record absolutely nothing. In this lecture he will use the million-volt high-frequency coil, one of the largest ever shown on the lecture platform. The enormous discharge produced, as shown by the picture, is brilliant and resembles a gigantic electrical tree.

Friday evening Dr. Strong will tell of "Life and Intelligence in the Unseen." Having proved the existence of life in realms beyond our normal sight or hearing, the next step is to show the existence of intelligence behind that life, since where life is, there intelligence must precede the life. Men of science have for years been investigating the subjects of vibration, finally reaching the conclusion that different planes of consciousness correspond to differing rates of vibration. Under suitable conditions this theory may be easily proven to be fact. Dr. Strong will show by electricity just how matter and force, which are too subtle—vibrating too rapidly for the physical senses to grasp, can be rendered perceptible by laboratory means. Beautiful experiments with ultra-violet rays will be shown, also the method by which science has made the human aura visible.

Saturday evening, March 31, the subject will be "The Science of the New Age." Here Dr. Strong will discuss the process long known to occultists, now just beginning to be accepted by scientists, whereby direct knowledge can be gained of higher planes of life, through development of powers existing in man's organism, but latent in the average individual. These faculties have long been recognized by students of "occult chemistry." The existence of etheric and supergaseous matter will be demonstrated by a series of experiments that fairly open up a new world. The possibilities of this superphysical world, on which Edison, Marconi, Tesla and other great scientists have drawn, will be presented by Dr. Strong in a manner at once clear and interesting, and this lecture is considered an important extension of and an addition to the latest scientific knowledge along these lines. These spectacular experiments reveal the fact that just beyond the vibrations of sight, hearing and touch, just beyond the realm of the visible, audible and tangible, lie vast fields that man has not begun to explore. New and fascinating fields of thought and speculation open up. The conditions of man's life, present and future, are suggested with a force and rational interpretation that offer unusual interest.

The series will conclude with a description of an imaginary visit to the scientific laboratory of the future.

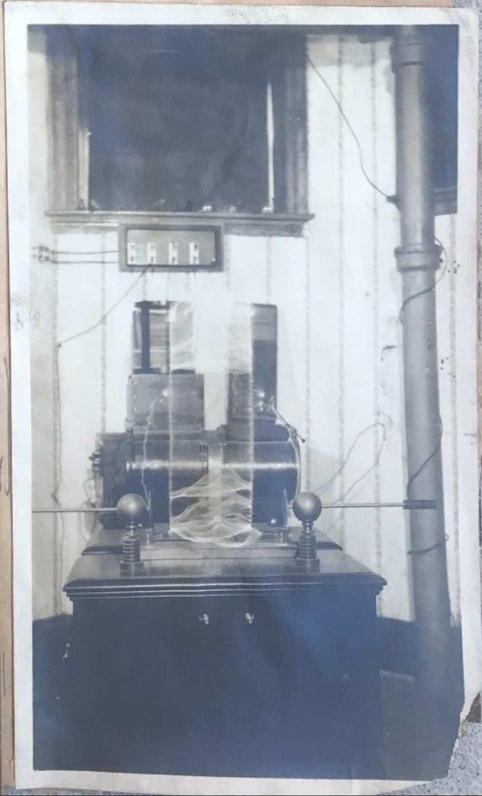
The Boston Transcript, referring to Dr. Strong's lectures, recently said: "A few decades ago science attempted to interpret life and consciousness in terms of matter and force; today we recognize matter and force as manifestations of life, even ... through

Dr. Strong's Million-Volt Coil Discharging Electricity





PROF. FREDERICK F. STRONG.




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...AKER TELLS ALL ABOUT THEOSOPHY

Dr. Strong Predicts That Intuition Will Replace Reason in Future.

In the third lecture of his series in Odd Fellows' Hall, last night, Dr. F. F. Strong foretold that the knowledge of the future would be obtained through intuition and not through the laborious materialistic processes of the 19th century, an age devoted to reason.

In his previous lectures of the course, Dr. Strong had demonstrated the possibilities of bringing inharmonious wireless instruments in accord, through the agency of step-down or step-up transformers. One of his demonstrations last night was halted until the tuning coil was adjusted to bring part of the apparatus in full rapport, after which the experiment proceeded smoothly. This was purposely shown, to enable the audience to follow the "tuning up" process of these transformers. The people of the future, Dr. Strong predicted, would be able to attune themselves when suffering from inharmonious vibrations, and the process would be accomplished by means of "step up" transformers located in the brain of every individual, these "transformers" being known to medical science under the names of the pituitary body and the pineal gland, which are organs for the senses of inner sight and inner hearing—or the true intuition.

Alcohol and tobacco, said Dr. Strong, have very bad effects upon the pineal gland and the pituitary body, the organs of intuition and if indulged in by those who are endeavoring to develop these bodies, the results would be serious, producing cerebro spinal meningitis and other mental troubles. That is why theosophy puts universal brotherhood at its first principle and requirement of membership, and a clean, unselfish life as requisites before attempting to develop these powers latent in all, for only with the development of character in tune with the infinite is it safe to force one's evolution to such an extent.

The purpose of theosophy, Dr. Strong said, was in order to make life more harmonious and to be of service to humanity.

This evening Dr. Strong will conclude his course in Springfield with a free lecture in Odd Fellows' Hall, outlining the theosophic schemes of life and the plan of evolution in which Theosophists believe.

WILL SEE THOUGHTS

Dr Strong Predicts Future Scientific Developments in Theosophical Lecture

"One hundred years from now a lecturer in addressing his audience will speak no word. Instead we will watch his thoughts in the air." This prophecy was made by Dr Frederick Finch Strong of Tufts medical college, Boston, in the third of his series of lectures under the auspices of the Theosophical society in Odd Fellows' hall last evening. Dr Strong explained that with the occult science mastered in a century from now we would be able to read the thoughts of persons without difficulty. He also stated that the etheric aura which surrounds everyone would be plainly visible to the naked eye.

Brilliant experiments were shown with electrical apparatus demonstrating the existence of etheric and supergaseous matter. Dr Strong said that, with the training of certain parts of the brain, communication with the spirits in the astral plane would be established. Such training, he said, would result from concentrated study, ... could be applied by anyone physi... and morally fit. Dr Strong will ... last of his lectures to-night ... Fellows' ... where he will ... how ... lec-







THEOSOPHICAL LECTURE.

Dr. Frederick F. Strong delivered the last of a series of lectures on Theosophy in Odd Fellows' Hall last night before a capacity house. His subject last night was "The Science of Life from a Theosophical Standpoint." "While Theosophy is the occult science of today," he said, "it is destined to be the orthodox science of the future. It is not a religion, but a science which helps people to understand their own religion."





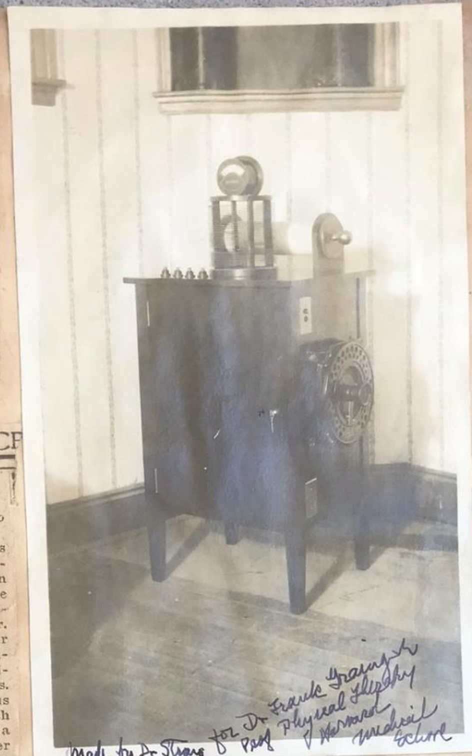
ELECTRICAL LECTURER

Strong Will Be in High School Monday Evening

Dr. Frederick Finch Strong, for eight years lecturer on electricity at Tufts college, Boston, is coming to Holyoke Monday evening to speak on "The Science of the New Age,"

Dr. Strong has been giving a most interesting course of lectures in Springfield the past week in Odd Fellows Hall and brings to Holyoke the famous million volt high frequency coil which he had in Springfield and which produces a discharge like a huge Christmas tree.

Other experiments and demonstrations will be given and Holyoke students may look forward to a treat in this lecture which will be given Monday evening in the High school. The lecture is free to all.





YOKE DAILY TRANSCR

THE SCIENCE OF THE NEW AGE.

Noted Electrical Lecturer Coming to Holyoke Monday Evening.

Dr. Frederick Finch Strong, who has been giving a series of unusually interesting lectures on electricity in Springfield this week, will give a free public lecture in Holyoke Monday evening in the Holyoke high school. Dr. Strong for eight years held the Chair of Electro-Therapeutics at Tufts Medical college, Boston, and is a well-known lecturer on electrical subjects. He will bring to Holyoke his famous million-volt high frequency coil, which produces an electrical display like a Christmas tree, and will conduct other experiments and demonstrations of an equally interesting nature. His subject will be "The Science of the New Age."

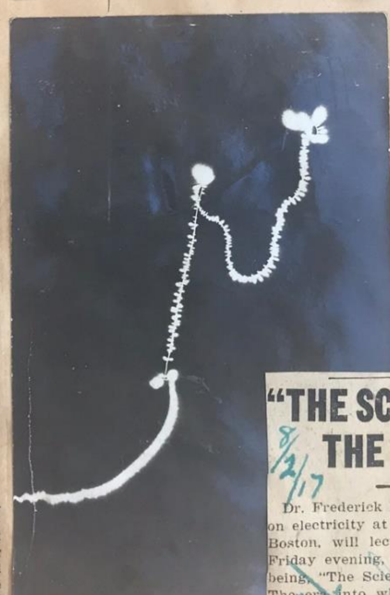




DR. F. F. STRONG.

The lecture will be of undoubted interest to High school students and electrical experts as well. Dr. Strong is a noted authority on this subject and has made a deep study of the force we call electricity, but which in spite of its daily use remains a mystery today so far as physical senses can penetrate.

Next fall, Dr. Strong has promised to come to Holyoke with the same service he has been giving in Springfield this week and students may look forward to his return visit with anticipation.



"THE SCIENCE OF THE NEW AGE"

8/2/17

Dr. Frederick Finch Strong, lecturer on electricity at Tufts Medical school, Boston, will lecture at Greenacre on Friday evening, August 3, the subject being, "The Science of the New Age." The era into which the world is entering bids fair to inaugurate revolution in all fields of human thought and activity; this is already apparent in the changed attitude of eminent scientific men towards the deeper things of life and it is not too much to say that the results of modern laboratory research have infused a note of spirituality into the hitherto materialistic realm of physical science

damental truths of religion. Wonderful and beautiful experiments are shown illustrating the recent discoveries which have carried scientific minds out of the real of "dead" matter into a world of ever-living, ever-manifesting spirit.

In this lecture, Dr. Strong will use his million volt high frequency coil, one of the largest ever shown on the lecture platform. It gives a radiating, tree-like discharge of electric flame over three feet high. The lecture will begin promptly at 8 p. m. and will be given in the Eirenion, the Greenacre lecture hall. All Greenacre lectures are free to the public who are cordially invited to attend.


Made by Dr Strong for Dr Frank Granger
Prof Physical Therapy
Harvard Medical School


damental truths of religion. Wonder-

The Realms Beyond the Senses

The Reality of the Unseen

A SERIES OF THREE LECTURES BY

Dr. Frederick Finch Strong

LECTURER ON ELECTRICITY
TUFTS MEDICAL COLLEGE, BOSTON

Monday, Wednesday and Friday Evenings

October 15, 17 and 19, 1917, at 8:15 o'clock

Auditorium of Public Library
Franklin Avenue near Fulton Street, Brooklyn

Given under the auspices of the Theosophical Society
95 Lafayette Avenue, Brooklyn

The general purpose of Dr. Strong
"Occult" Science of today will be t
morrow, and to indicate by brilliant ar
of the ways through which this change

Will Talk on Vibration.

Dr. Frederick Finch Strong, of Tufts College, will lecture on "The Realty of the Unseen Vibrations of Nature" on October 15, 16, and 17, at 8:15 in the evening, in the Brooklyn Public Library, Franklin Avenue and Fulton Streets. Dr. Strong will use a million-volt high-frequency coil, and the ultra-violet ray in demonstrations which he will give.



DR. STRONG TALK ON UNSEEN REALITIES

"The reality of the unseen" was the topic of Dr. Frederick Finch Strong's lecture, under auspices of First Spiritual church, 55 Pearl street, last night.

Our physical bodies, according to Dr. Strong, may be compared to overalls. We don them and come on earth to dig in the trenches. When the labor is over the overalls are cast aside and man stands in his spiritual underclothes, a reality but as yet invisible to the material eye.

Hundreds of scientific men, says Dr. Strong, who have passed years of study and investigation along the line of psychic phenomena are emphatic in their statements of the spiritual life of man on earth, even after he has passed thru what is called, or miscalled, death. The men who voice these opinions started their researches as rank materialists, sceptic.

Men are born unequal, according to science, and the only logical way to account for the difference in the mental and spiritual caliber of the great financier and the day laborer is thru the theory of former existence and life on this earth. The brain of the financier is keener and more fully developed simply because he has lived longer, has had more lives than the day laborer.

Science has proved that there are vibrations so powerful around us at all times that it is beyond our physical senses to see or hear them, to be aware of their presence in any way, except thru a scientific vibratory transformer. These vibratory transformers are beyond the grasp of the lay mind. We cannot understand the technical side of the question because we have not been trained along scientific lines. Dr. Strong, by several spectacular experiments, left no doubt in the minds of the audience regarding the existence of the ultra-violet ray," a higher and more powerful vibration than the famous "violet ray."

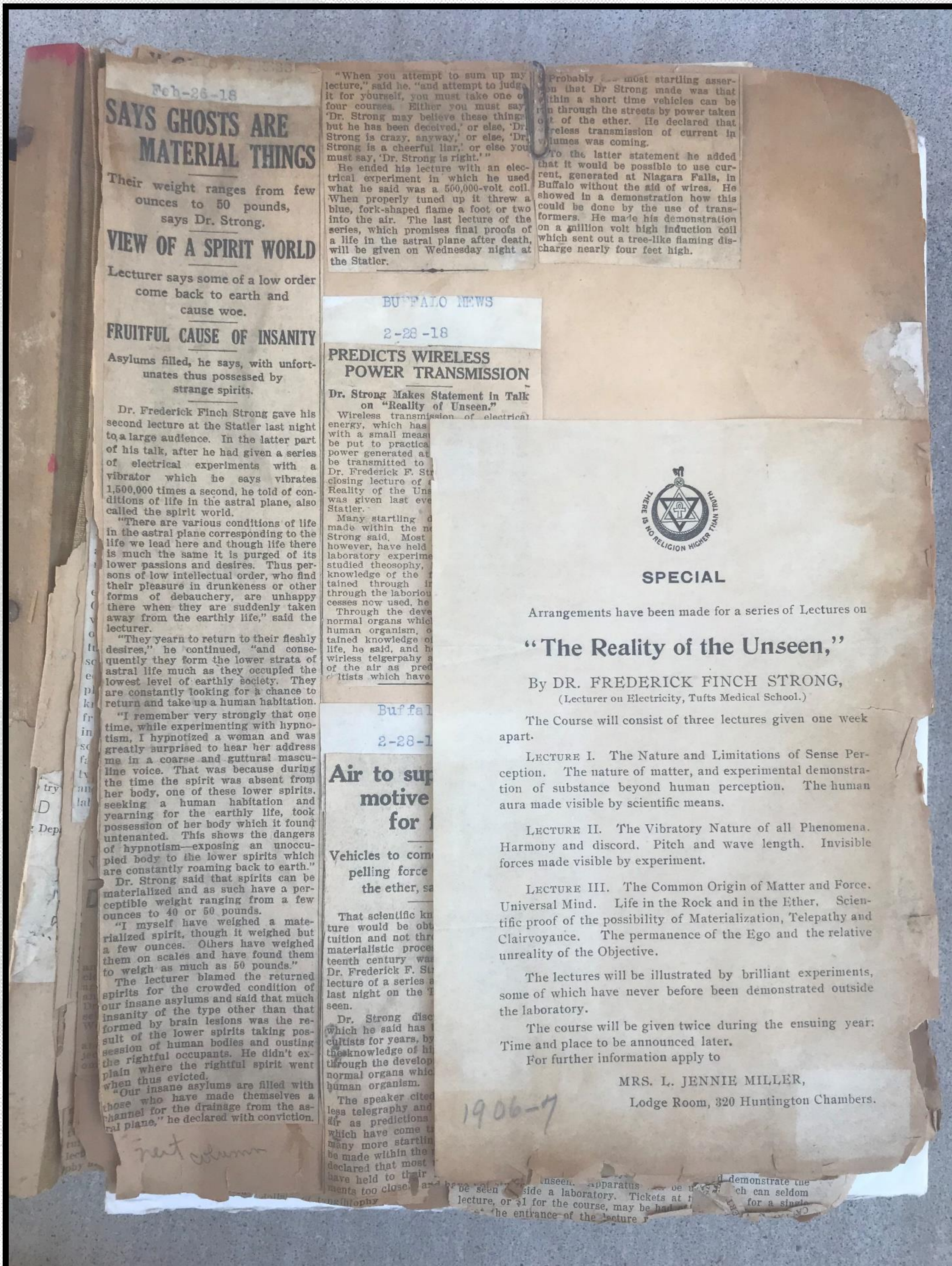
Altho the public mind cannot often follow the scientific end of the story, still the public mind accepts the scientific proofs of the unseen reality of these powerful vibrations. Why does the public mind turn a deaf ear to science when, speaking from deep study and investigation, it tells of a material life, on a higher and invisible plane, it is true, but nevertheless a real life after the physical overalls have been laid aside?

All around us, says Dr. Strong, are the astral bodies of friends and relatives who have done their bit in the trenches of life, and now stand in spiritual underclothes. We cannot see them because the matter which shapes their bodies is to fine for the physical eye, just as the ultra-violet ray was invisible to the senses.

There are some people who are sensitive to the unseen realities. These are the psychics or mediums. They the the vibratory transformers of the psychic world.

Dr. Strong concluded with wonderful experiments with the ultra violet ray, laboratory proof of the lecture's theory of the existence of forces and matter beyond the earthly senses.

Dr. Strong will lecture on the "Star of the east," at the First Spiritualist church, Dec. 2. The third and last of the series of "Realms beyond the senses," will be held the second Wednesday in January.



Feb-26-18

SAYS GHOSTS ARE MATERIAL THINGS

Their weight ranges from few ounces to 50 pounds, says Dr. Strong.

VIEW OF A SPIRIT WORLD

Lecturer says some of a low order come back to earth and cause woe.

FRUITFUL CAUSE OF INSANITY

Asylums filled, he says, with unfortunates thus possessed by strange spirits.

Dr. Frederick Finch Strong gave his second lecture at the Statler last night to a large audience. In the latter part of his talk, after he had given a series of electrical experiments with a vibrator which he says vibrates 1,500,000 times a second, he told of conditions of life in the astral plane, also called the spirit world.

"There are various conditions of life in the astral plane corresponding to the life we lead here and though life there is much the same it is purged of its lower passions and desires. Thus persons of low intellectual order, who find their pleasure in drunkeness or other forms of debauchery, are unhappy there when they are suddenly taken away from the earthly life," said the lecturer.

"They yearn to return to their fleshly desires," he continued, "and consequently they form the lower strata of astral life much as they occupied the lowest level of earthly society. They are constantly looking for a chance to return and take up a human habitation.

"I remember very strongly that one time, while experimenting with hypnotism, I hypnotized a woman and was greatly surprised to hear her address me in a coarse and guttural masculine voice. That was because during the time the spirit was absent from her body, one of these lower spirits, seeking a human habitation and yearning for the earthly life, took possession of her body which it found untenanted. This shows the dangers of hypnotism—exposing an unoccupied body to the lower spirits which are constantly roaming back to earth."

Dr. Strong said that spirits can be materialized and as such have a perceptible weight ranging from a few ounces to 40 or 50 pounds.

"I myself have weighed a materialized spirit, though it weighed but a few ounces. Others have weighed them on scales and have found them to weigh as much as 50 pounds."

The lecturer blamed the returned spirits for the crowded condition of our insane asylums and said that much insanity of the type other than that formed by brain lesions was the result of the lower spirits taking possession of human bodies and ousting the rightful occupants. He didn't explain where the rightful spirit went when thus evicted.

"Our insane asylums are filled with those who have made themselves a channel for the drainage from the astral plane," he declared with conviction.

"When you attempt to sum up my lecture," said he, "and attempt to judge it for yourself, you must take one of four courses. Either you must say, 'Dr. Strong may believe these things but he has been deceived,' or else, 'Dr. Strong is crazy, anyway,' or else, 'Dr. Strong is a cheerful liar,' or else you must say, 'Dr. Strong is right.'"

He ended his lecture with an electrical experiment in which he used what he said was a 500,000-volt coil. When properly tuned up it threw a blue, fork-shaped flame a foot or two into the air. The last lecture of the series, which promises final proofs of a life in the astral plane after death, will be given on Wednesday night at the Statler.

Probably ... most startling assertion that Dr Strong made was that within a short time vehicles can be run through the streets by power taken out of the ether. He declared that wireless transmission of current in volumes was coming.

To the latter statement he added that it would be possible to use current, generated at Niagara Falls, in Buffalo without the aid of wires. He showed in a demonstration how this could be done by the use of transformers. He made his demonstration on a million volt high induction coil which sent out a tree-like flaming discharge nearly four feet high.

BUFFALO NEWS

2-28-18

PREDICTS WIRELESS POWER TRANSMISSION

Dr. Strong Makes Statement in Talk on "Reality of Unseen."

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2-28-1...

Air to sup... motive ... for ...

Vehicles to com... pelling force ... the ether, sa...

SPECIAL

Arrangements have been made for a series of Lectures on

"The Reality of the Unseen,"

By DR. FREDERICK FINCH STRONG,

(Lecturer on Electricity, Tufts Medical School.)

The Course will consist of three lectures given one week apart.

LECTURE I. The Nature and Limitations of Sense Perception. The nature of matter, and experimental demonstration of substance beyond human perception. The human aura made visible by scientific means.

LECTURE II. The Vibratory Nature of all Phenomena. Harmony and discord. Pitch and wave length. Invisible forces made visible by experiment.

LECTURE III. The Common Origin of Matter and Force. Universal Mind. Life in the Rock and in the Ether. Scientific proof of the possibility of Materialization, Telepathy and Clairvoyance. The permanence of the Ego and the relative unreality of the Objective.

The lectures will be illustrated by brilliant experiments, some of which have never before been demonstrated outside the laboratory.

The course will be given twice during the ensuing year. Time and place to be announced later.

For further information apply to

MRS. L. JENNIE MILLER,

Lodge Room, 320 Huntington Chambers.

1906-7

the Statler.

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next column

BUFFALO NEWS

2-28-18

PREDICTS WIRELESS POWER TRANSMISSION

Dr. Strong Makes Statement in Talk on "Reality of Unseen."

Wireless transmission of electrical energy, which has been accomplished with a small measure of success, will be put to practical uses so that the power generated at Niagara Falls can be transmitted to Buffalo wirelessly, Dr. Frederick F. Strong predicted in a closing lecture of a series on "The Reality of the Unseen." The lecture was given last evening in the Hotel Statler.

Many startling discoveries will be made within the next few years, Dr. Strong said. Most research scientists, however, have held too closely to their laboratory experiments and have not studied theosophy, he said. Scientific knowledge of the future will be obtained through intuition and not through the laborious materialistic processes now used, he declared.

Through the development of supernormal organs which are latent in the human organism, occultists have obtained knowledge of higher planes of life, he said, and he cited the X-ray, wirless telgerpahy and the navigation of the air as predictions of the occultists which have come true.

Buffalo Express

2-28-18

Air to supply motive power for future car

Vehicles to come will grab propelling force right out of the ether, says scientist.

That scientific knowledge in the future would be obtained through intuition and not through the laborious materialistic processes of the nineteenth century was the statement of Dr. Frederick F. Strong in his closing lecture of a series at the Statler hotel last night on the Reality of the Unseen.

Dr. Strong discussed a process, which he said has been known to occultists for years, by which may obtain the knowledge of higher planes of life through the development of the supernormal organs which are latent in the human organism.

The speaker cited the X-ray, wireless telegraphy and navigation of the air as predictions of the occultists which have come true. He said that many more startling discoveries will be made within the next few years and declared that most research scientist[illegible] have held to their laboratory expe[illegible] ments too close[illegible] [illegible] ophy

Who Lectures at Lindell Hall Next Week.



Dr. Strong holds degrees from leading universities here and abroad, and is the inventor of the "Violet Ray," also the first apparatus to generate Tesla currents for the X-Ray.

H[illegible]mes to Lincoln next week and [illegible] give a unique lecture at the Lind[illegible] Hall on "The Realms Beyond [illegible]e Senses." He is recognized as o[illegible] of the leading electrical auth[illegible]ties, is the author of many scien[illegible]ic text-books, and for some year[illegible]as been lecturer on electricity [illegible] Tufts college, Boston. Dr. [illegible] was consulted as an ex[illegible] the Submarine Defense as-[illegible] regarding the [illegible]

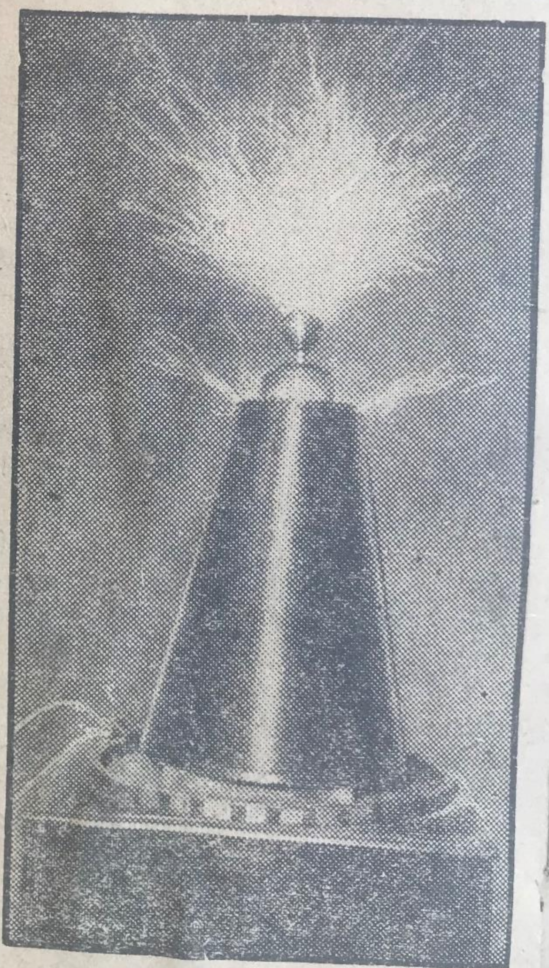
A series of three lectures by

DR. FREDERICK FINCH STRONG

Lecturer on Electricity, Tufts College, Boston

LINDELL HALL, MAY 7, 8, 9, 8:15 p. m.

With brilliant electrical experiments Dr. Strong will prove that just beyond the realm of sight, hearing and touch, just beyond the visible, audible, tangible, lies a wonderful world that science is just beginning to explore. He will show how science has demonstrat-



Dr. Strong's million-volt coil in action, giving a tree-like flaming discharge

'Invisible' Is Visualized

Ethereal Magnetic Waves From Human Body

FIRST Published Photograph ((Exclusive to the "Examiner") of the Invisible Emanations From Human Body, Discovered by Dr. F. Finch Strong, Which He Says Are the Hitherto Unknown Magnetic Forces Employed in Healing. This Photograph Was Taken by Proefssor W. Scott Lewis of Dr. Strong's Hands by Means of the "Violet Rays"—or Vacuum Electrode—Which Was Dr. Strong's Invention and Is Used by the Entire Medical Fraternity for Healing Purposes Throughout the World.



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3:00 P. M. 2130 North Vista Del Mar Ave.,
Hollywood, Cal.

A. P. WARRINGTON, Vice-President

A. F. KNUDSEN, Dean

Phone 57552

Sunday Afternoon, July 6, at 3 o'Clock

DR. FREDERICK FINCH STRONG

National Lecturer for the Theosophical Society

Topic: "THE PSYCHOLOGY OF LAZINESS"

The principle of Inertia, from the standpoint of physics and of occultism—with experiments.

Buffalo News- July 10-19

BUF

TALKING TO DEAD BE WIRELESS POSSIBL

Experiment With Transformer Process Being Worked Out to Solve Mysteries.

That communication with the dead may be made as commonplace a matter as is wireless communication with a person in Europe at the present time, was the remarkable statement made by Dr. Frederick Finch Strong, of the Krotona Institute of Theosophy at Hollywood, yesterday.

Experiments have been made there, it was announced, demonstrating the methods which, when further extended, it is argued, will accomplish this amazing result.

Is the human eye too dull to observe shapes and forms which people the world; do the dead of the past and present stalk around us in our everyday existence, and will the human mind prove acute enough to extened the functions of the limited

May Reveal New Human Forces.

The Krotona experiments give rise to the hope that a technique, whereby new forces and kinds of matter may be revealed and even the spirts of the departed communicated with, will be perfected.

A sort of transformer process for the dull senses is being worked out in the hope of proving by means of actual communication with the dead the theory held concerning the continuity of life after death.

Dr. Strong lectured yesterday on the subject, "Direct Communication With the Dead by Wireless Methods: A Scientific Possibility of the Future." W. Scott Lewis, registrar of Krotona Institute and secretary of the Bureau of Science, has worked on many of these experiments.

What Lights Do We Not See?

One experiment which leads to the belief that any number of things may be camouflaged under a kind of color which makes it impossible for the eye to detect is with ultra-violet rays. Rare minerals, which respond to certain wave lengths, take up and transform them so that they become visible.

This presents the question: "How many kinds of light are there that the human eye does not register—what reposes beneath the surfaces at which humans gaze as though blind?"



P.A. Evening Herald
July 19, 1919

SCIENTISTS IN SEARCH FOR OUR ASTRAL DOUBLES

Believers in Theosophy Plan Sanitarium for Study of Etheric Problems

To demonstrate the actual existence of man's etheric double and to establish a sanitarium for the metaphysical diagnosis and treatment of disease is the task which Dr. Frederick Finch Strong, national lecturer of the Krotona Institute of Theosophy, has undertaken, according to announcement today.

That every visible body has its aura, or etheric double, is the opinion of Dr. Strong. It is conceived as a faintly luminous bluish-grey mist, ordinarily unperceptible to the human eye. But Dr. Strong believes he will be able to demonstrate its existence beyond any question.

"Occultism has long maintained that every visible object has its duplicate in grades of matter too fine for ordinary human perception," declared Dr. Strong.

SEES DOUBLE

"A few years ago Dr. Kilner of London discovered a screen that operated as a medium for making visible the etheric double of man. The screen proved effective with about 60 per cent of the persons using it and in our classes at Krotona we have succeeded to an even greater extent."

"Many of my students see colors as well as the steel grey of the etheric double," continued the doctor. "And when they have attained this, who knows but they will be enabled to sense even finer matter than the etheric?"

When the philosophers have so progressed they are clairvoyant and astral matter is within their grasp, says the doctor.

IN CLOUD OF LIGHT

That every human, every animal even every tree, is surrounded by a cloud of light, has already been proved to the satisfaction of the Theosophists, while manifestations of the vital force in the human is conspicuous as a constant stream of particles of a pale-rose color which flows over and through the body along the nerves even as the blood corpuscles flow along the arteries.

This luminous cloud extends 18 inches from the body in all directions and is therefore approximately oval ... hence called the auric egg.

And within the auric egg are ... inter-auras. Thus say the Theosophists who today are eagerly watching for the shadows of their etheric doubles on the ghostly screen of Dr. Strong.

The health aura, the magnetic flame aura, the emotional mirror aura, the aura of the lower mind, the aura of the reincarnating soul, and—mystery of mysteries—the sixth and seventh auras! For beyond the fifth aura hangs a veil beyond which even the scholars have as yet dared not penetrate.

PLAN SANITARIUM

Meanwhile, that none may accuse the Krotona colonists of being impractical, Dr. Strong announces that it is the present plan of the Institute to found a sanitarium in which proven methods of metaphysical diagnosis and treatment as well as proved methods of practices of the "regular schools" will be employed.

"The value of clairvoyant vision for purposes of diagnosis in medicine has been established," said Dr. Strong. "One Los Angeles physician has already become famous for his color system of diagnosis.

"The screen for the showing of the etheric double should be in use among the physicians. The technic of the invention is such as to make it available for any physician to use, for it absolutely does not depend upon the finer vision of the operator.

FINDER OF DISEASE

"The presence of a disease may be determined by the patient's reaction to color beyond a doubt and his recovery hastened if not completely accomplished by the application of complementary colors."

Thus while the more advanced students and philosophers are beholding their etheric doubles, novices at the institute are lounging by the lotus-pool, immersed in the bizarre text-books regarding the auric egg.

Thick black clouds in the aura usually indicate hatred and malice, say these books.

Deep red flashes on a black ground show anger, but noble indignation is differentiated by a brilliant scarlet flash. Lurid, flaming red indicates animal passions. Dull brown-red, almost rust color, shows avarice, while dull, hard brown-gray indicates selfishness.

Heavy leaden gray expresses deep depression, whereas livid gray—a most hideous and frightful hue—shows fear.

Gray-green shows deceit; brownish green, with occasional dull-red flashes, betokens jealousy; crimson—love. Rose color tinged with lilac shows the spiritual love for humanity.

Orange, if clear, shows ambition. If tinged with brown, pride. Yellow expresses intellectuality; bright green, ingenuity; dark, clear blue, religious feeling, and light blue, ultramarine or cobalt shows devotion to a noble spiritual ideal and gradually rises to a luminous lilac-blue which indicates the higher spirituality and is almost always accompanied by sparkling golden stars.

ETHERIC DOUBLE OF MAN VISIBLE TO HUMANS, CLAIM

Have you ever seen your etheric double, or is it possible you did not know you had one? To demonstrate the existence of such a vehicle is the purpose of a class in etheric vision now being conducted by Dr. Frederick Finch Strong at Krotona Institute of Theosophy.

"Occultism has long maintained that every visible object has its duplicate in grades of matter too fine for ordinary human perception," declared Dr. Strong. "A few years ago Dr. Kilner of London discovered a screen that operated as a medium for making visible the etheric double of a human being. The screen proved effective with about 60 per cent of the persons using it, and in our classes at Krotona we have succeeded to an even greater extent."

Etheric Colors Seen

Many of Dr. Strong's pupils see colors as well as the steel gray of the etheric double, the doctor said, and these colors he believes to evidence their ability to sense even finer matter than the etheric. He calls that grade astral matter, and the people who can see it, he says, are clairvoyants, who are seeing the astral body.

The practical value of having clairvoyant vision for purposes of diagnosis in medicine has been proven, the doctor maintains, in the cases of numerous members of the medical profession. Basing his experiments on clairvoyant vision a Los Angeles doctor, who has since become famous for his color system of diagnosis, has been able to perfect what has so far proven to be, it is claimed, an infallible method for diagnosing disease.

Available For Practice

Dr. Strong stated the technic of the invention was such as to be available for anyone in the practice of medicine and that it did not depend on the "finer vision" of an operator for its success. According to this man's idea not only the presence of a disease may be discovered by a patient's reaction to colors, but his recovery from the trouble may be hastened, if not completely accomplished by the application of complimentary colors.

Dr. Strong says it is the present plan of Krotona Institute to found a sanitarium in which proven methods of metaphysical diagnosis and treatment as well as the demonstrated practices of the "regular schools" will be employed.

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Opening of the New Community Center

July 3, 1919
8 p.m.

(near Hollywood Blvd. and Western Ave.)

of Hollywood especially invited

PROGRAM

Popular Trio

Frederick Finch Strong. Subject: "The New Age."

JULY, 1919

Sunday Public Services

KROTONA INSTITUTE of THEOSOPHY
Mrs. Annie Besant, President

THE TEMPLE

North Vista Del Mar Ave., Hollywood, Cal.

A. F. KNUDSEN, Dean

Phone 57552

July 6, at 3 o'Clock
FREDERICK FINCH STRONG
the Theosophical Society
"PSYCHOLOGY OF LAZINESS"
Inertia, from the standpoint of Occultism—with experiments.

AUGUST, 1919

Sunday Public Services

KROTONA INSTITUTE of THEOSOPHY
Mrs. Annie Besant, President

THE TEMPLE

3:00 P. M.

2130 North Vista Del Mar Ave., Hollywood, Cal.

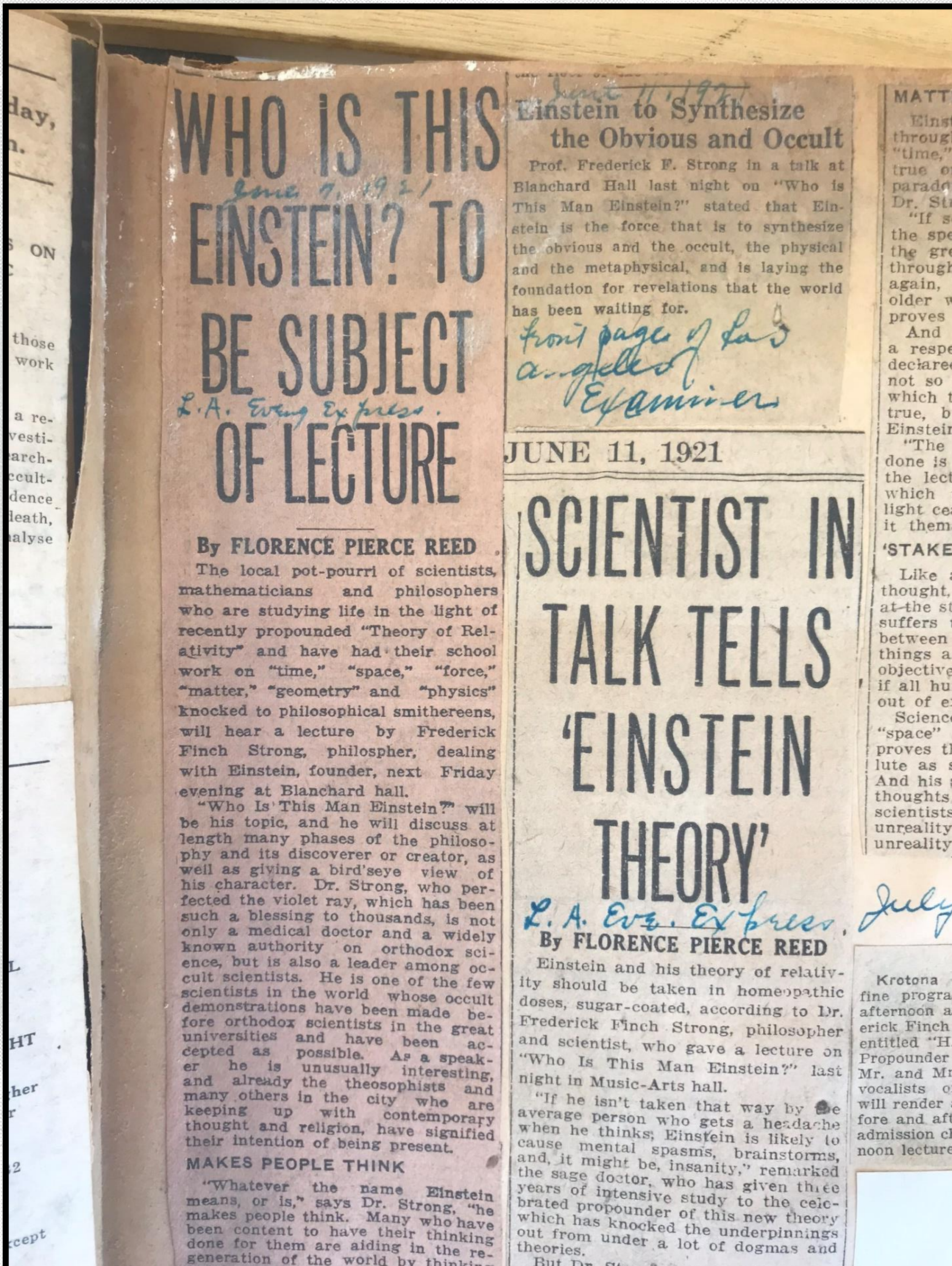
A. P. WARRINGTON, Vice-President

A. F. KNUDSEN, Dean

Phone 57552

Sunday Afternoon, Aug. 3, at 3 o'Clock
DR. FREDERICK FINCH STRONG
Topic: "THE POWER OF THE SPOKEN WORD," with Experiments Illustrating Forms Built by Sound Waves

Dr. F. F. ... of Palmetto, and his assistant Chas. Haley, arrived Friday, and the Dr. contributed a rare evening's lecture in the entertainment section of the Bazaar. Many have expressed regrets at not hearing the Dr., and hope he may be induced to come at some future time.



WHO IS THIS EINSTEIN? TO BE SUBJECT OF LECTURE

June 7, 1921

L.A. Evening Express.

By FLORENCE PIERCE REED

The local pot-pourri of scientists, mathematicians and philosophers who are studying life in the light of recently propounded "Theory of Relativity" and have had their school work on "time," "space," "force," "matter," "geometry" and "physics" knocked to philosophical smithereens, will hear a lecture by Frederick Finch Strong, philospher, dealing with Einstein, founder, next Friday evening at Blanchard hall.

"Who Is This Man Einstein?" will be his topic, and he will discuss at length many phases of the philosophy and its discoverer or creator, as well as giving a bird'seye view of his character. Dr. Strong, who perfected the violet ray, which has been such a blessing to thousands, is not only a medical doctor and a widely known authority on orthodox science, but is also a leader among occult scientists. He is one of the few scientists in the world whose occult demonstrations have been made before orthodox scientists in the great universities and have been accepted as possible. As a speaker he is unusually interesting, and already the theosophists and many others in the city who are keeping up with contemporary thought and religion, have signified their intention of being present.

MAKES PEOPLE THINK

"Whatever the name Einstein means, or is," says Dr. Strong, "he makes people think. Many who have been content to have their thinking done for them are aiding in the regeneration of the world by thinking

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June 11, 1921

Einstein to Synthesize the Obvious and Occult

Prof. Frederick F. Strong in a talk at Blanchard Hall last night on "Who is This Man Einstein?" stated that Einstein is the force that is to synthesize the obvious and the occult, the physical and the metaphysical, and is laying the foundation for revelations that the world has been waiting for.

front page of Los Angeles Examiner

JUNE 11, 1921

SCIENTIST IN TALK TELLS 'EINSTEIN THEORY'

L.A. Eve. Express. July

By FLORENCE PIERCE REED

Einstein and his theory of relativity should be taken in homeopathic doses, sugar-coated, according to Dr. Frederick Finch Strong, philosopher and scientist, who gave a lecture on "Who Is This Man Einstein?" last night in Music-Arts hall.

"If he isn't taken that way by the average person who gets a headache when he thinks; Einstein is likely to cause mental spasms, brainstorms, and, it might be, insanity," remarked the sage doctor, who has given three years of intensive study to the celebrated propounder of this new theory which has knocked the underpinnings out from under a lot of dogmas and theories.

But Dr. Stron...

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This method—employed by the writer for years—enables us to obtain the wonderful *vitalizing effect* of the high-frequency currents on the whole body simultaneously,

By careful tuning a beautiful effect may be obtained. Close examination of this discharge will show it to be literally an electric "brush", formed of thousands of



FIG.1

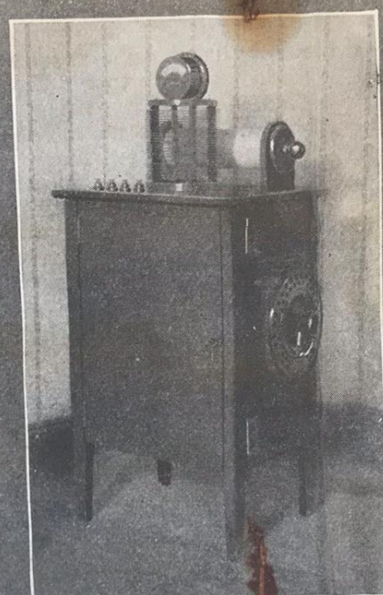


FIG.



FIG.4

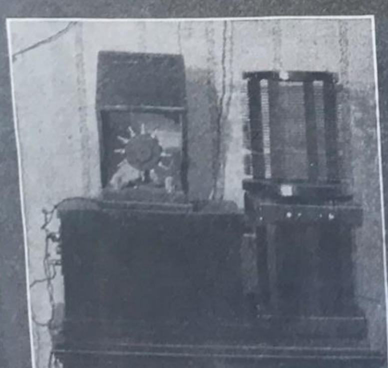


FIG.2

The Accompanying Illustrations Show Some of the Spectacular Electric Spark Discharges Obtained From the High-Frequency Apparatus Used by Dr. Strong In His Lecture and Electrotherapeutical Work. The "Ladder of Sparks" in Figs. 3 and 4, Is easily Produced, the Tesla Spark Simply Jumping the Gap Between Two Vertical Copper or Iron Wires.

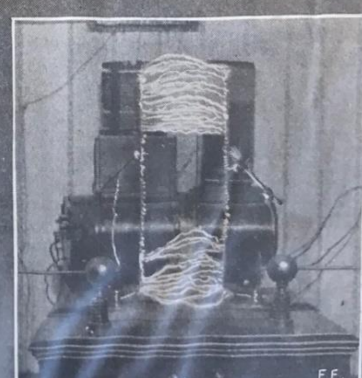


FIG.3

e terminal of
metal electrode
of thin nickeled
g and 1½ inches
e current is dif-

with the local effects from the vacuum electrode.

For the past few years the writer has been in the habit of connecting the Tesla coil with an *Auto-condensation pad* (as used in the "D'Arsonval" and "Diathermic" methods). This is formed of two plates of Bakelite ¼ inch thick ...

distinct, delicate, purple threads. Upon each of these hair-like paths of light countless millions of *ions* (electrically-active atoms), are being shot from the electrode to the patient at a speed of over 60,000 miles per second; the treated surface is therefore being submitted to a literal bombardment ...

How to Use High Frequency Currents in the Treatment of Disease

By Dr. FREDERICK FINCH STRONG.
Lecturer in Electrotherapeutics, Tufts Medical School, Boston

NOW that the exigencies of war have temporarily suspended the activities of amateur Radiotelegraphers, many of those possessing transmitting outfits are using them for the experimental study of the phenomena of High Frequency currents.

In the ELECTRICAL EXPERIMENTER for May, 1917, the writer described the construction of a Tesla D'Arsonval high-frequency outfit made from standard "Wireless" apparatus, consisting of a ¼ or ½ K.W. transformer with glass plate condenser and oscillation transformer, the latter used as a series inductance to obtain various effects from the Tesla coil, or as a "D'Arsonval Solenoid" for obtaining the "Diathermic" and "Auto-condensation" currents so valuable in the treatment of certain diseases.

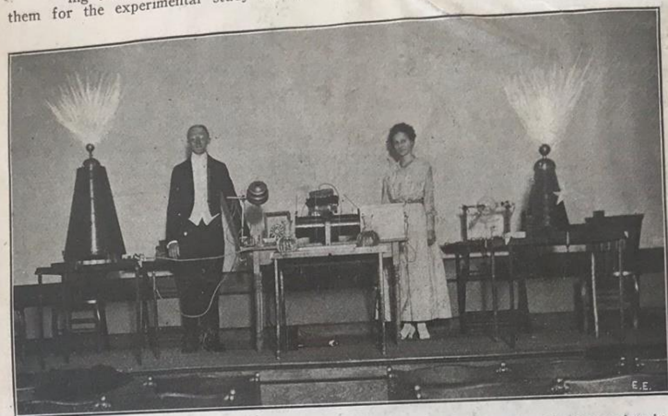
Many excellent results can be obtained from high-frequency treatment administered by those who have little or no knowledge of medicine. A physician's advice should always be obtained before undertaking the treatment of any serious case, but the amateur may safely employ moderate doses of Tesla currents, and even mild diathermy and autocondensation, provided he makes himself reasonably familiar with the elementary principles of electrotherapeutics.*

In a few States there is a law prohibiting the therapeutic use of electricity by any but licensed physicians, but even this would not apply to treatments given gratuitously by amateurs to relatives or friends. A number of the writer's former pupils have become successful practising electrotherapeutists, altho they are not physicians. Most of them wisely refrain from the use of the sinusoidal, Galvanic and static currents; these belonging more to the field of the electro-medical specialist.

A simpler and cheaper apparatus than the one described in the May issue of this journal will give all the varieties of therapeutic high-frequency currents that may safely be used by the amateur. It is made up as follows:—

Transformer,—Any standard ¼ K.W. radio transformer (E. I. Co., Clapp-Eastham, Thordarson, etc.)

Condenser,—Standard wireless glass plate condenser, one section of .005 microfarad; two sections of .01 m.f., each in series will be safer.



This Photo Shows Dr. and Mrs. Strong with the Elaborate Apparatus Used in Lecturing in Different Cities. Note the Large Conical Oudin Coils in Full Activity.

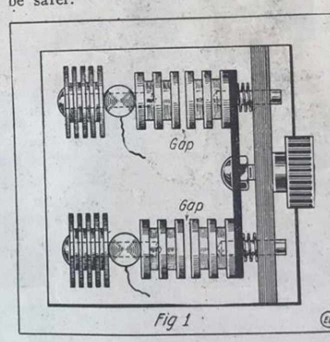


Fig. 1. A Simple Form of Fixt Spark Gap, Found Very Satisfactory for High Frequency Outfits.

Inductance Coil, ("D'Arsonval" solenoid), thirty turns No. 12 bare copper wire, wound around a wooden cage 8" in diameter., ¼" between turns.

Spark gap,—Adjustable series gap, made as shown in the diagram, Fig. 1. The sparking surfaces are of copper, turned in annular or concentric grooves as described in a previous article. Copper washers of ½" and 1" diameter, are slipt alternately on an 8-32 machine screw, and form the heat radiating wings. The further construction and operation of the gap is indicated in the drawing.

Tesla Coil,—Identical in winding to that previously described, viz.,—secondary—on a 2" diameter paper mailing tube wind 480 turns of No. 34 S. C. C. magnet wire (40 turns to the inch; 12" winding, 1" margin on each end). Slip the secondary into a 4" mailing tube, center accurately by means of three corks in each end, seal one end by standing coil on end in a shallow pan filled with melted resin, and when cold fill the annular space between tubes with a mixture of beeswax (yellow) one part, to resin, 5 parts. Wind primary, consisting of six turns "Magneto" cable (which can be bought for five cents a foot) around center of outer tube; turns spaced ½" apart. Secondary leads, of magneto cable, should be connected to the outer posts of the writer's "triple terminals." One arrangement of the complete apparatus is shown in Fig. 2. The triple terminals greatly facilitate the therapeutic use of the Tesla Currents, and also afford an opportunity for studying different forms of the high-frequency discharge. The actual terminals, A and C, are formed of two moulded high-tension insulators, surmounted by 2" brass bed balls, (known to the furniture trade as "brass vases"); thru terminal A slides a brass rod having a rubber or hard-wood handle on the outer end, and a 3" flat brass disc on the inner end. Terminal C is similar but has a small brass ball on the inner end of the sliding rod. A "Dummy" terminal, B, is mounted as shown, midway between the actual terminals. By closing the gap between the brass discs and opening that between the balls B and C, an arc discharge is obtained, while by closing gap B C, and separating the disc electrodes, the discharge forms a beautiful purple brush or "effluve."

In giving treatments the patient is seated on a folding *condenser pad* of thin fibre of Bakelite, Fig. 4, backed with copper or tin foil to which is attached an insulated cord connected with terminal C. The operator will require a set of vacuum electrodes, Fig. 5, a metal hand electrode formed of an eight-inch length of 1¼" nickeled brass pipe, "effluve" electrode made from the gong of an old electric bell screwed on the end of a hard-wood handle and two pieces of sheet block tin 3" x 3" x 1/32" with insulated conducting cords soldered to their corners, Fig. 6. The condenser-pad can be obtained from any electro-therapeutical supply house, as also the vacuum electrodes and other materials.

For ordinary general treatment to promote nutrition, increase circulation and elimination—a treatment of value in almost any condition of impaired health—the balls and discs are widely separated and

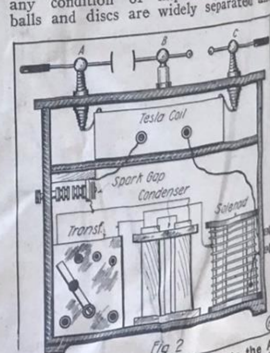


Fig. 2. Assembly of Apparatus in the Author's High Frequency Therapeutic Outfit.

* The new edition of the writer's book, "Essentials of Modern Electrotherapeutics," now in press, gives all needed information, with an alphabetical list of various diseases and the method of treating them electrically.

the patient is seated on the condenser pad connected to the terminal C. Open the spark gap until a vacuum electrode lights up when held about a foot from the patient: this shows that the body is being charged inductively to a high potential, the charges alternating some 1,500,000 times per second. The patient feels nothing and is absolutely insulated from all electrical connection with the apparatus, yet hot sparks can be drawn from any part of the body showing that the whole organism is being subjected to a rapidly alternating molecular massage, which has the effect of increasing all the vital functions without acting as a stimulant. In other words the treatment tends to bring the patient into a normal condition, but it has no more effect upon a perfectly healthy person than pouring water into a pail already full. This is the reason why high frequency treatments may be safely given by those who are not physicians, whereas all other forms of therapeutic currents act as stimulants or counter-irritants and must be employed with precise knowledge and discrimination.

The condenser treatment as described above, is usually given for about fifteen minutes after which the bulb-shaped vacuum electrode is applied for a few minutes over the spine and solar-plexus. It is applied either directly to the surface of the body or thru one thickness of clothing. The insulating handle of the vacuum electrode is connected to the middle post B, in Fig. 2, and after turning on the current and placing the electrode on the patient, the discs A and B, are closed, being opened again before lifting the electrode from the surface of the body: if this is not done painful sparks will pass from the glass electrode to the patient. In treating obstinate cases of recurrent neuralgia, chronic rheumatism and partial paralysis, this vacuum sparking treatment is often beneficial, but it is rather unpleasant for most cases. A milder form of this counter-irritant effect is obtained by using the vacuum electrode over two or three thicknesses of clothing; it must be moved rapidly from place to place, otherwise the skin might be blistered.

For sedative effects and to reduce local inflammation and congestion, the vacuum electrode should always be applied directly to the skin or mucous membrane; this applies to such conditions as acute rheumatism, neuritis, tonsilitis, etc., an acute "cold in the head" (coryza) can often be aborted in one treatment by the above technique, using the vacuum electrode over the nose and the thin slender vacuum electrode in the nasal cavity.

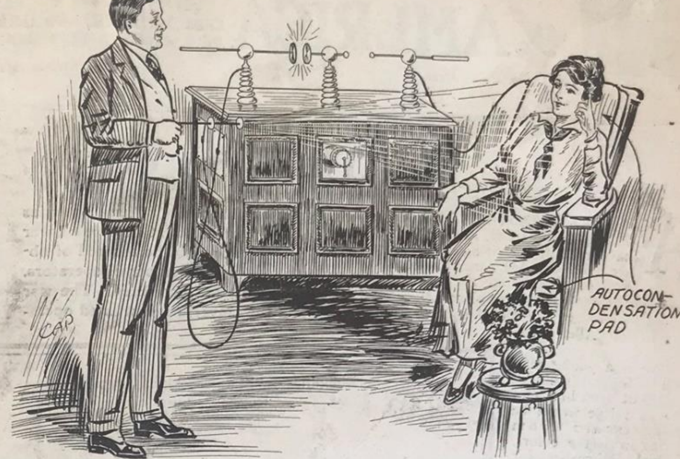
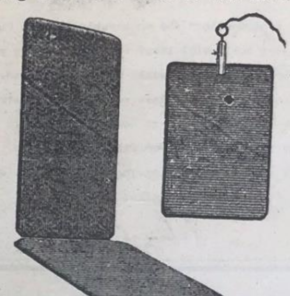


Fig. 3. Showing How a Patient Is Given the High Frequency "Effluve" or Spray Treatment. The Patient Sits on a Folding Condenser Pad Placed in the Chair.



Figs. 4 and 6. Condenser Pad Used for Giving Auto-Condensation Treatment and Auxiliary Tin Electrode.

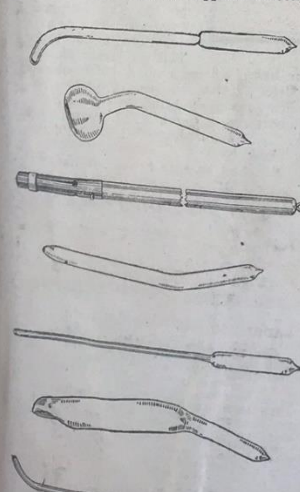


Fig. 5. Various Forms of High Frequency Treatment Electrodes. They Are Made of Glass.

In treating skin diseases, such as eczema and acne, where we wish to avail ourselves of the antiseptic and tonic effects of the "effluve," we connect the effluve electrode in place of the vacuum electrode, close the discs and gradually approach the bell of the electrode to the patient until a full, blue violet effluve plays upon the surface to be treated (see Fig. 3). To obtain the best effluve effects several turns of the tuning coil should be used in series with the Tesla primary (see article in May issue). The effluve is also valuable as a general tonic in sluggish conditions of the digestive system, also in nervous depression and functional nervous diseases.

For the relief of abnormal arterial tension—("high blood-pressure"), and in the treatment of *arteriosclerosis,* as well as in conditions involving excess of uric acid, we employ "D'Arsonval autocondensation." To obtain this current we short-circuit the Tesla primary by means of the single-throw switch, and attach the condenser pad to the lowest turn of the "Solenoid" or tuning coil. The patient clasps both hands around the metal "pipe" electrode connected to the upper turn of the coil, the current is turned on and the spark-gap opened until a pleasing sensation of warmth is felt flowing up the patient's arms. In all regular therapeutic high-frequency outfits, a hot-wire milliamperemeter is placed between the patient and the machine. This is not necessary in connection with the above described apparatus, as it only delivers a maximum of 800 milli-amperes to the patient—an amount well within the limits of safety. In chronic cases autocondensation should be given daily in twenty-minute treatments. This treatment should never be given immediately after eating, or in cases of "Bright's Disease," or in organic heart trouble. High frequency treatments are of great value even in these conditions, but they should be applied only by a skilled specialist.

In inflammation following acute infection, as in acute bronchitis, incipient pneumonia, etc., we employ "local autocondensation" or "indirect Diathermy." In this method the patient sits upon the pad as for autocondensation, but instead of the metal handle we employ one of the plates of block tin; this is applied in close contact with the skin over the affected area, covered with a folded towel and held in place by the patient; a sensation of deep penetrating heat is felt, and relief from the pain and congestion follows. This is one of the most valuable methods in electrotherapeutics; were it available for the general practitioner, or better still, in the patient's home, there is no doubt but that nine-tenths of the cases of acute local infectious disease could be aborted. This is also of great value in the treatment of asthma.

Statistics show that one-seventh of all recorded deaths are due to Pulmonary Tuberculosis ("Consumption,"): proper treatment in the home by high frequency currents would greatly increase the percentage of recoveries from this dread disease. Dr. Howard Van Renssellaer of the Albany Tuberculosis Hospital has reported 80% of cures by high frequency treatment, and an even higher percentage is reported by Dr. Alfred Geyser of New York. The writer feels that this subject is of sufficient importance to be treated in a separate article, which will appear in next month's ELECTRICAL EXPERIMENTER under the title "The Home Treatment of Tuberculosis with High-frequency Currents."

Monochromatic Light

An Entirely New Field Appears to Be Opened for Investigation In Monochromatic Light Group

FREDERICK FINCH STRONG, M. D.

The Cinema is the child of Cinematography and Cinematography is the direct offspring of Light.

Metaphysically speaking, Light is **a state of consciousness** and true light is also Color; white light being the simultaneous consciousness of all colors. Physically speaking, light corresponds to a single octave of electro-magnetic vibrations, but this force does not produce light,—it **induces** or **evokes** its manifestations in the consciousness of the man himself.

Whatever we may think of man's true nature it will be conceded that he is neither ether-vibration, retina, nerves nor brain;—he **uses these.** Nor is he any or all of the states of color-consciousness which we call light; —he **experiences** these. The Immortal Spectator and Enjoyer of the Cosmic Cinema—**this** is the REAL MAN!



Dr. F. F. Strong

The language of light is sevenfold—the spectral colors of Newton. But we have to record this language on the tablets of consciousness by means of an occular typewriter having but three keys. The generally accepted "Young-Helmholtz" theory of vision postulates three end-organs or antenna for each retinal nerve unit. These correspond to Orange, Green and Violet. Simultaneous excitation of all three evoke white light in consciousness. Excitation of Orange and Green give subjective Yellow, Orange and Violet give Red, and Green and Violet induce the Blue sensation.

Science has reduced all ponderable matter to units of electricity—the Proton and the Electron. The electron is a unit of negative charge, groups of moving electrons constituting all types of electrical currents. The Proton is known in the free state only in the form of the Hydrogen Ion. These two are the primitive building blocks of the material universe. According to the generally accepted "Bohr Theory" the atoms of all the chemical elements are miniature solar-systems, each atom consisting of one or more protons as central suns around which revolve various numbers of planetary electrons in definite orbits. Bombardment of atoms by free electrons (electrical currents) cause some of the planetary electrons to jump from one orbit to another. The values of many of these "jumps" have been accurately determined, and the "splashes" they produce in the universal space-filler, the hypothetical ether, correspond to the single wave-lengths, the "Bright Lines" of the spectrum of gases.

What a light-wave really is is still a matter of speculation; about all that we can say is, that while sound waves are in one dimension, and water-waves in two dimensions, light energy is a three-dimensional wave. The phenomena of polarization prove this last statement.

Spectra may be divided into three general classes:—

1. **Continuous Spectra:** Emitted by incandescent solids such as tungsten filament in a "Mazda" lamp. Such a spectrum begins in the Infra-red and extends through all wave-lengths in the visible region up to about 3400 A. U. in the Ultra-violet. Light of this type, when the spectral values are balanced may appropriately be called artificial daylight and would appear to best be suited to the requirements of Cinematography.

2. **Band Spectra:** Emitted from gases heated to incandescence or from electrified **molecular** gases in a "vacuum tube" (all gases except hydrogen and the other monatomic gases). The spectrum of the **flame** of a carbon arc is of this class. (The incandescent ends of the carbons, of course, giving out a continuous spectrum.)

3. **Bright-line Spectra:** Emitted from electrified gases in the **atomic** state. These spectra are formed of chords, or mathematically related single wave-lengths. About the only practical sources of monochromatic light (from single wave lengths) are vacuum tubes containing the monatomic gases Helium, Neon, or Argon at pressures of about 10 mm., excited by a transformer current of from ten to fourteen-thousand volts. By adding metallic mercury to such a tube the electrified gas knocks out mercury ions and the tube then emits the familiar bright line spectrum of mercury similar to that produced by the Cooper Hewitt Arc, but without the large percentage of heat and infra-red rays generated by the latter.

The writer has devised a series of sixteen filters for use in connection with these vacuum tubes. The filters consist of various standard colored gelatine films, such as those used in theatrical lighting, in combination, or used in connection with various commercial colored glasses. In this manner it is possible to obtain single-wave monochromatic light in any part of the visible spectrum. Light of the following wave-lengths has been produced:

1. Red, 7032 A. U. (from Neon).
2. Orange, 6382-04 A. U. (Neon).
3. Yellow, 5790-69 (Neon-mercury) or 5876 A. U. (from Helium).
4. Green, 5461 A. U. (Neon-mercury).
5. Blue, 4348-59 A. U. (Neon-mercury).
6. Violet, 4047-78 (Neon-mercury).

To obtain a sufficiently powerful source of light the luminous tubing is formed into a close spiral about 15″ long by 3″ diam. representing a tube length of about fifteen feet. Many uses for this light will doubtless be found in psychological and biological laboratories and very important and interesting results may be expected from future research work.

In order to obtain and investigate the therapeutic effects of monochromatic light the writer has employed groups of adjacent lines in different spectral regions. One filter used with a Neon unit gives a very powerful orange red free from all other colors. It results from eighteen bright-lines. No data is available at the present time as to the physiological and therapeutic properties of this group, but these are being studied. These lines give a dominant hue of about 6300 A. U., corresponding to the first Young-Helmholtz Primary.

A yellow-green group formed from the mercury yellow and the green lines has a dominant hue of about 5600 A. U., corresponding to the Second Primary. This light has been found to be a powerful stimulant to cell reproduction, especially in connection with plant growth. Clinically it has given excellent results in the treatment of redundant scars, and skin diseases where it is desired to induce normal cell production. It promises well.

The third Young-Helmholtz primary is obtained by the use of the writer's "No. 1" Filter used in connection with a Neon-mercury generator. Its visible lines are the Blue 4359-48 A. U. and the Violet double line 4078-47 A. U. Spectrograms made at the Physics Department of the Univ. of Calif. of L. A. by Dr. Ellis show that in addition to the last mentioned visible lines, there is transmitted the powerful Ultra-violet triplet, 3663-44 A. U. The presence of this wave is also demonstrated by the brilliant yellow fluorescence of Willemite and Uranium glass.

Mr. Joseph Dubray has made a series of interesting photographic studies with these three ray-groups which

Light Radiations and Photography

Technical Editor

Under this pompous title, which would presuppose the writing of many volumes, the writer presents a few of a series of photographs taken recently in the cabinet of Dr. Frederick Finch Strong, of Hollywood, under well defined spectral radiations. The illustrations on the opposite page are more eloquent than any written word and a simple description of the conditions under which they were taken will prove undoubtedly more interesting than a long and dry sequence of words without the accompaniment of the visual interpretation of their meanings.

Dr. Strong is an eminent practitioner and has carried on for several years thorough investigations on the therapeutic effects of different kinds of light radiations. His work has led him to the making of some light filters which transmit well defined spectral radiations.

The light units used are either a mercury vapor tube or a Neon gas tube of the type illustrated in the engravings. The filters are of gelatine dyed with carefully selected dyes and their transmission is determined by careful spectroscopic inspection.

The two pictures at the top of the page show Dr. Strong with his small spectroscope, examining the radiations emitted by the lights which in these two cases are: at the left a blue-violet and at the right a deep red monochromatic radiation.

The lights actually shown in the picture were the sole illuminant used in taking the pictures. Panchromatic plates were used.

Note the difference in value of the draped curtain in the background which was of a rather dark blue color.

The other illustrations present pictures of a chart made of colored woolen materials, the colors corresponding to each segment being readable on the chart itself.

The picture at the left in the middle row was taken with the mercury vapor tubes and the one at the right, in the same row, was taken with the Neon tubes, both lights unfiltered.

The difference of rendition of the color values are so evident that no comment is necessary.

The illustrations of the bottom row are pictures of the same chart taken with lights of the following radiations:

The picture at the left: Blue-violet and ultra-violet end of the spectrum showing the three following lines: Blue 4358 A. U., Violet 4078-47 A. U., Ultra-violet triplet 3680-50 A. U.

The visual dominant hue of the quality of light used in the taking of this picture is at about 4200 A. U. and the photographic energy peak is placed at about 4100 A. U.

The middle picture: Photographed through a yellow-green filter transmitting radiations corresponding to the two lines 5790 and 5461 A. U. with a visual dominant hue at 5500 A. U.

The picture at the right: Photographed through a filter transmitting the red-orange group of the spectrum, corresponding to twenty dominant lines in the Red, Orange and Yellow, from 7063 to 5000 A. U. The dominant visual hue being at about 6350 A. U.

No comment is necessary to emphasize the selective action of the filters and the response of the photographic material to the radiations transmitted by them.

The abridged Transaction of the Society of Motion Picture Engineers by Mr. L. A. Jones on light filters, which is being printed in the columns of THE AMERICAN CINEMATOGRAPHER at this time, treats the technical end of orthochromatic reproductions and distortions so thoroughly and clearly that the writer refers the readers to this transaction for all further information on the subject that he may desire.

Monochromatic Light

By Frederick Finch Strong

(Continued from Page 9)

are reproduced in connection with his article in this number of THE AMERICAN CINEMATOGRAPHER.

Eight months' experience in the clinical use of the "Blue Ultra-violet" Light (the ray-group last mentioned), have developed some surprising facts. It appears to promote all normal vital processes, induce restoration of endocrine balance and adjust abnormal blood-pressure. It does not appear to act biochemically except indirectly, and is quite different from the shorter ultra-violet rays produced by the Quartz mercury arc. Hospital reports show that it allays pain and nervousness and induces natural sleep. It has been of especial value as an adjuvant in post-operative cases.

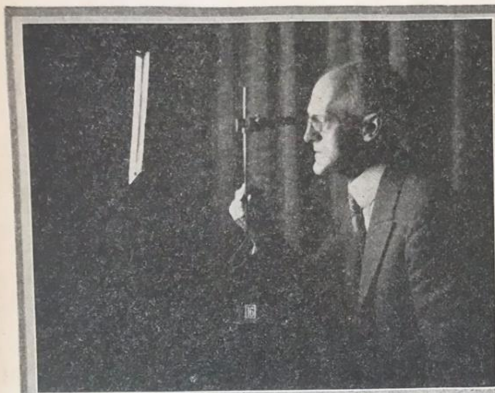
An entirely new field appears to be opened for the investigation of monochromatic light groups through this novel method of generation.

The results obtained with the "Blue Ultra-violet" combination call to mind an epigrammatic statement in an interesting book written in the early seventies:—

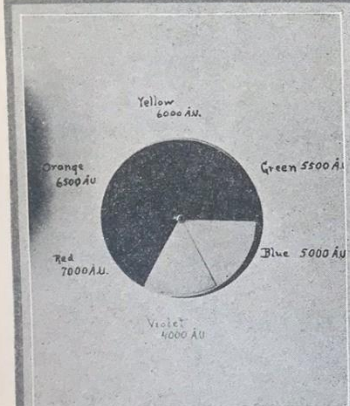
* "Light is Life.......Both are Electricity." (footnote) * From "Isis Unveiled," by H. P. Blavatsky; 1877.

Showmanship for Exhibitors

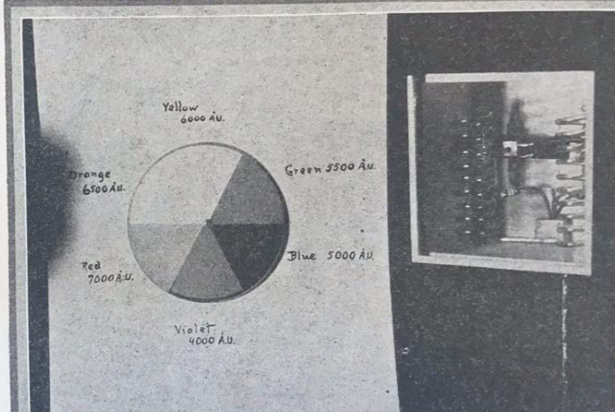
A complete new section of showmanship ideas will be found in the 1928 FILM DAILY YEAR BOOK published by THE FILM DAILY and which is now being distributed. These ideas are grouped so that the exhibitor who has a certain type of production to put over can quickly turn to that section and find countless ideas on how to exploit and sell his picture to his patrons. It has taken months and months to collect and prepare these many stunts for publication and the exhibitor who does not get for himself a copy of the 1928 FILM DAILY YEAR BOOK will be doing himself an injustice. These money making stunts are all practical, they are not just theory as so many stunts submitted to exhibitors are these days. They are presented briefly and clearly so that exhibitors may readily grasp the idea and put it into practice. This is only one of the many interesting features that will be found in THE FILM DAILY YEAR BOOK which is given free with each yearly subscription to THE FILM DAILY whose offices are located at 1650 Broadway, New York city.



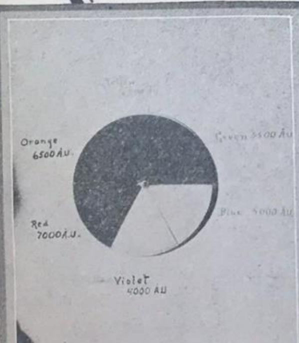




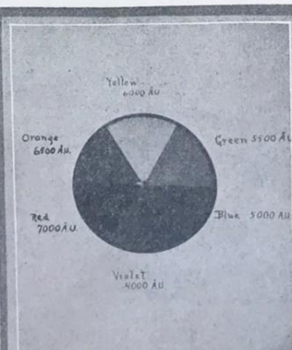
Photographed with an open Mercuy vapor tube



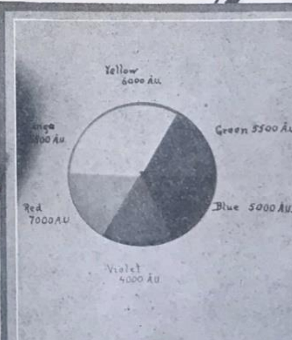
Photograped with an open Neon tube.



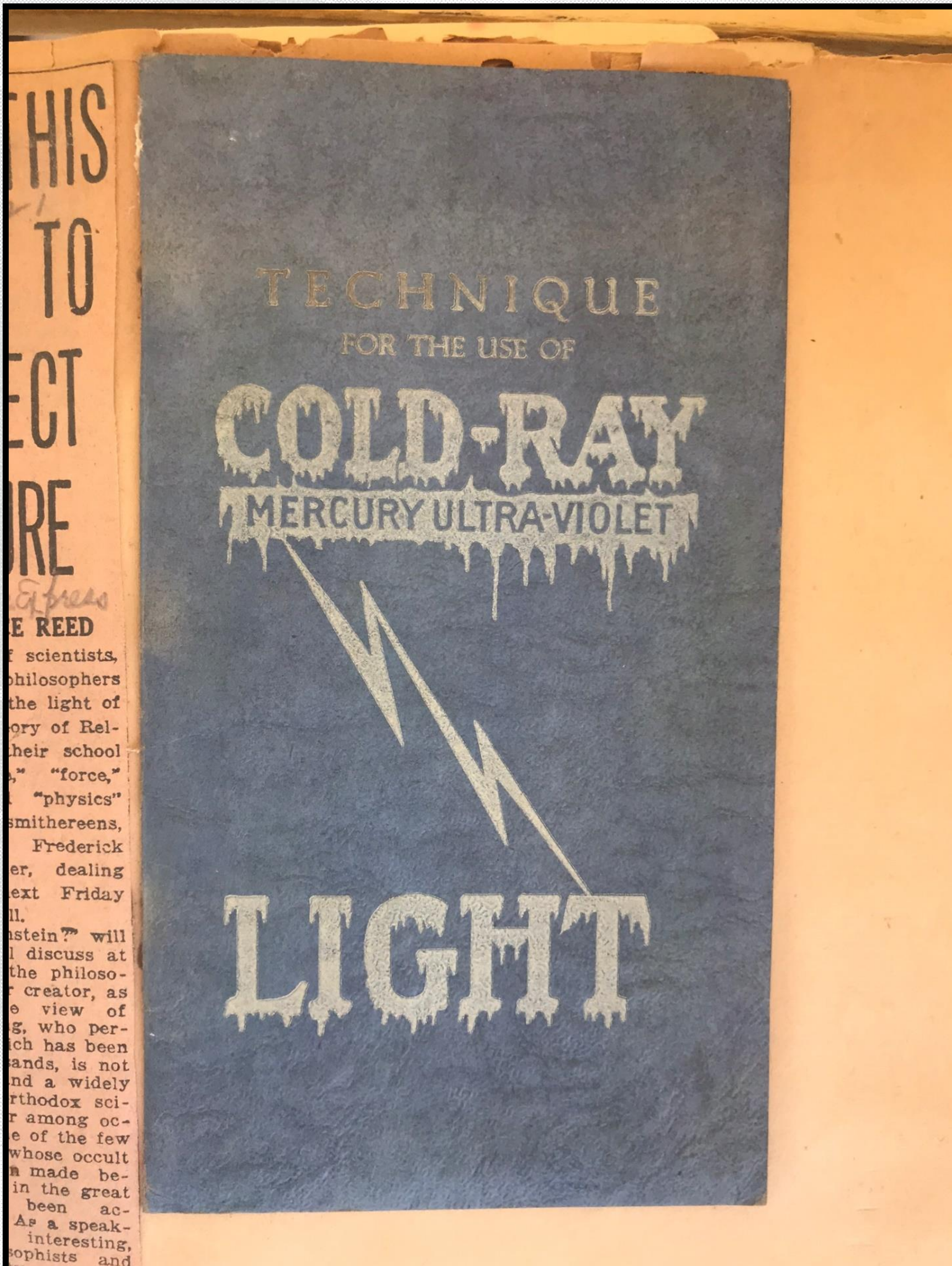
Blue Violet and Ultra Violet radiations



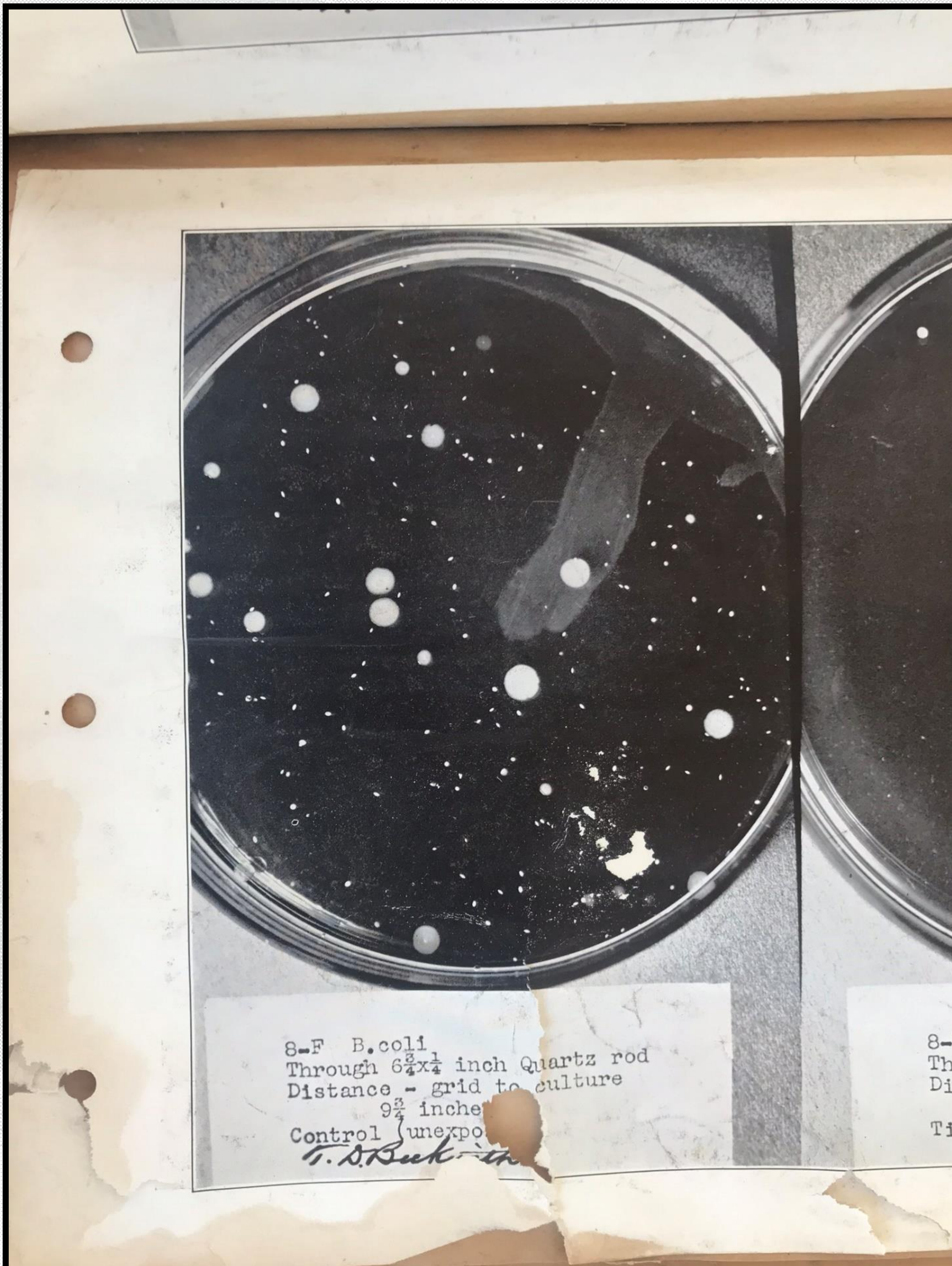
Yellow-green radiations



Red-Orange group radiations.
Photographed by Joseph A. Dubray A.S.C.


TECHNIQUE
FOR THE USE OF
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T. D. Beck

COLD-RAY ULTRA VIOLET LAMPS
ULTRA-VIOLET CORPORATION-LTD. LOS ANGELES

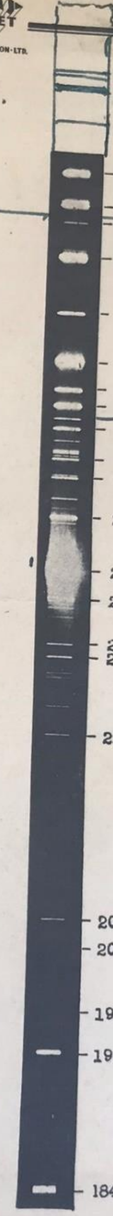
Ångstrom's Units

7200 (Positions – Red – in Sunlight

Visible Light-Octave.

Limit of Vision

(an angstrom unit is one ten-millionth of a millimeter)



Ultra-Violet Spectrum of Cold-Ray Ultra-Violet Quartz Lamps as shown by a Schumann photographic plate. Wave-length of prominent lines of the Spectogram has been indicated in Angstrum Units.

As compared with the Spectra of earlier forms of Ultra-Violet energy from mechanical sources, the Cold-Ray Spectrum is seen to represent an increase in energies effective in producing chemical change.

Spectrogram of Dr Strong's "Cold Quartz" Mercury Ultra-violet Radiation.

5790 5790 5436 4916 4358 B. 4078 4047

"Symphonic Healing"

A new method for the treatment of disease by the simultaneous use of musical, colored light, delicate perfumes, and electrical high-frequency currents, all the vibrations being harmonically related and attuned to the receptivity of the individual patient.

Health and Harmony are terms so frequently associated as to be often employed synonymously; without harmony perfect physical and mental health is impossible.

> "The Human organism may be compared to a symphony orchestra,—the different organs representing the various instruments, while the individual players may be likened to the nerves and ganglia governing each function, controlled and supervised by the conscious intelligence through the central nervous system (analogous to the Conductor, or Musical director). Suppression or alteration of any one function disturbs the equilibrium of the whole body, just as a single instrument playing out of tune will destroy the harmony of an entire orchestra." (Quoted from "Modern Electro-therapeutics," by Dr. F. F. Strong.)

The healing of discordant mental and physical conditions by the use of color, music, perfume, etc., was used as a method of therapeutics in Ancient Greece and was mentioned by Pythagoras and Hippocrates. It was used not only to restore but to promote and maintain physical and mental health. The recognition and use of this harmonic relationship between the human organism and its environment had undoubted influence in producing the perfection of body, clarity and poise of mind and flexibility of the emotions for which the ancient Greeks were noted.

The present age, with its crash and jar,—stress and strain,—headache and nerve tension,—is the direct antithesis of the "Golden Age" of Greece. That this era of iron and brass should have produced a type of disease unknown to previous periods is only natural when we consider the discord in our

environment and its effect on individuals. We are often called a "Race of Neurasthenics"; nervous exhaustion, insomnia, melancholia, etc., are manifestations of a too common condition resulting from our abnormal methods of life: (often called "Americanitis").

Music, flowers, cheerful surroundings, etc., have long been recognized as valuable factors in restoring nervous invalids to health, but the use of harmonically related vibrations of different types tuned and adapted to the various nerve centres of the patient is an entirely modern idea. It has recently been formulated into a scientific system, the remarkable results of which would seem to justify the correctness of the theory upon which it is based. Briefly stated this hypothesis is as follows:—For every individual there is a keynote or rate of vibration to which the various nerve centres normally respond, and which corresponds mathematically to a certain note in the diatonic or septenary scale. Occultists of all schools and even modern psychologists recognize this individual keynote, and it is a well known fact that themes played in a certain key will affect a given individual more intensely than if placed in any other part of the scale. Many celebrated composers have had favorite keys in which their best compositions were usually placed. Healing music must be produced from instruments like the organ which give sustained tones producing a sense of relaxation and repose, whereas the percussive effects as from the piano, mandolin, drum, etc., are exciting, and like all stimulants are followed by a weakening reaction.

In addition to the musical vibrations we have (1st) those which affect the sympathetic nerves controlling digestion and circulation; these are electrical vibrations and produce no conscious sensation; (2nd) light waves which produce harmonious effects through their respective colors; and (3rd) the complex vibrations of an (at present) unknown nature, which act upon the nerves of the sense of smell.

Dr. Frederick Finch Strong, lecturer on Electricity at Tufts Medical School, has been experimenting along these lines for the past fifteen years, and has perfected a system in which nervous and mental diseases are successfully treated by what is known as "Symphonic sensation." Every nerve centre of the patient is made to respond to the particular

keynote or rate of vibration which is found to produce the most perfect sense of rest and relaxation. The technique employed is as follows,—

The patient reclines upon a couch in the centre of a room the walls of which are draped in black; the ceiling is white and is illuminated indirectly by banks of lamps, every seventh lamp being of the same color; the colors employed are as follows, each color corresponding mathematically to a note in the diatonic scale:—Red, (C); Pink, (D); Orange, (E); Yellow, (F); Green, (G); Blue, (A); Violet, (B). This arrangement differs slightly from the spectral colors as ordinarily given: pink being introduced between the red and orange, and indigo being omitted. The couch upon which the patient reclines is connected with a special electrical high-frequency apparatus invented by Dr. Strong, which gives the seven rates of vibration corresponding to the diatonic scale of the twenty-first octave. These are used to restore or promote harmonious action in the nerve centres which govern organic function (digestion, circulation, etc.). The patient is first relaxed by a few minutes of general electric treatment. The room is then flooded with soft light, one tint after another, until a color is obtained which produces a sense of rest and harmony upon the patient. This is taken as the "keynote"; it varies with different patients, but is always the same for a given individual. Soft music is then played in a lower octave of the same key. Soft adagio effects from muted strings, and themes in major keys being usually selected. If a Victrola be used the correct key may be obtained by adjusting the speed of the motor. Still better results may be obtained from the instruments themselves if suitably played. The choralcelo, pipe-organ, harp, cello, violin and zither are the best instruments for the production of healing music.

The electrical apparatus is now adjusted to the "keynote" of the patient in the appropriate octave. For example, if the patient is most effectually relaxed and rested by soft blue light his "keynote" will be registered as "A": (blue, in the color scale,) (light vibrations are in the 49th octave.—from three hundred trillion to six hundred trillion per second.) Music is then played in the key of A Major,—the patient's musical taste being consulted in the selection of the composi-

tion. Musical vibrations or sound waves occupy eleven octaves and range from 16 to 32,000 vibrations per second. The Electrical oscillations are made to vibrate to the "A" of the twenty-first octave,—the "C" of which is about one million per second. Seven distinctive and delicate perfumes—true floral perfumes,—not coal tar substitutes,—are arranged in flasks connected with a nebulizer and compressed air tank. We have no "perfume scale" but by experiment we usually find for each patient a particular floral fragrance which is soothing and restful. Heavy scents are not to be used,—only a trace of fragrance,—a mere flower-breath,—is necessary. When this is determined and employed we have the patient's consciousness receiving simultaneously or "symphonically" soothing and restful vibrations effecting the centres of sight, sound, smell and vitality. The sense of luxurious relaxation and harmony is most grateful to a nerve-racked patient, and is a most delightful and restful experience even for a perfectly healthy individual.

While designed especially for the treatment of nervous and mental derangements, this method has proved of great value as a natural sedative in the relief of pain and congestion. In these latter conditions local electrical treatment may be used in addition to the general routine.

A complete equipment for this method of healing is being installed in the new University of Music at 221 Newberry St., Boston. Dr. Strong will have personal charge of the work and will receive patients for treatment daily except Sundays. All treatments by special appointment. The prominent musicians connected with the University will furnish music in special cases.

For terms, appointments, or arrangements for private demonstrations of the new Symphonic Healing, apply to

PROFESSOR ROBERT DOUGLAS,
University of Music of America,
221 Newberry St.,
Boston, Mass.

DEPARTMENT OF MEDICAL THERAPY or SYMPHONIC HEALING

—o—

Dr. Frederick Finch Strong, Lecturer on Electricity at Tufts Medical School, in charge of this department, has been developing this system for the past fifteen years. He is well known as a pioneer in electricity as applied to human healing, especially so in his successful work with what is known as "high frequency currents," and has perfected something for which the world has been waiting for centuries.

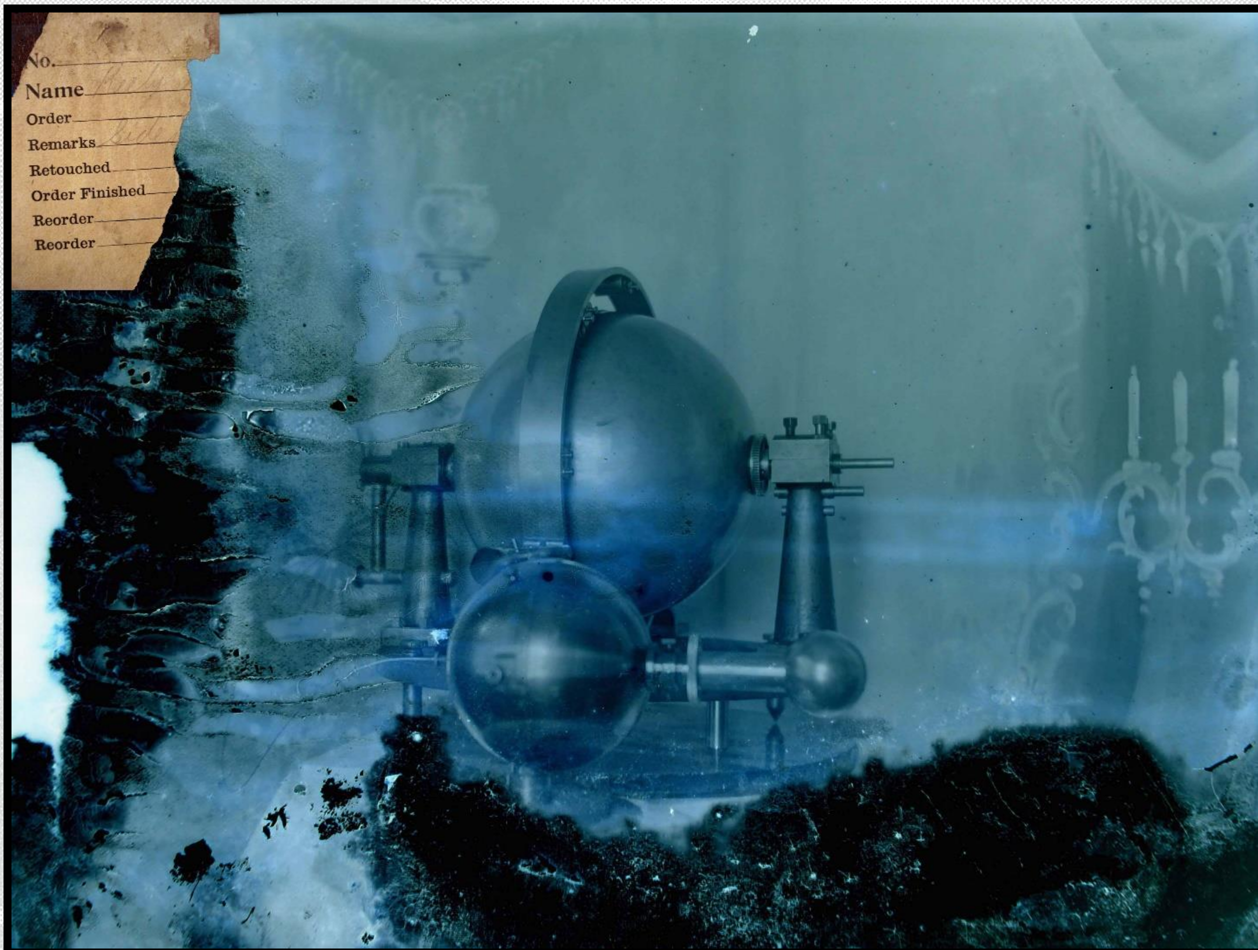
The present age with its crash and jar,—stress and strain,—headache and nerve tension, is urgently in need of new and rational methods of treatment. For those who are unfortunate enough to possess sensitive, high-strung temperaments, especially to the overworked musician and singer, this department will come as a veritable boon.

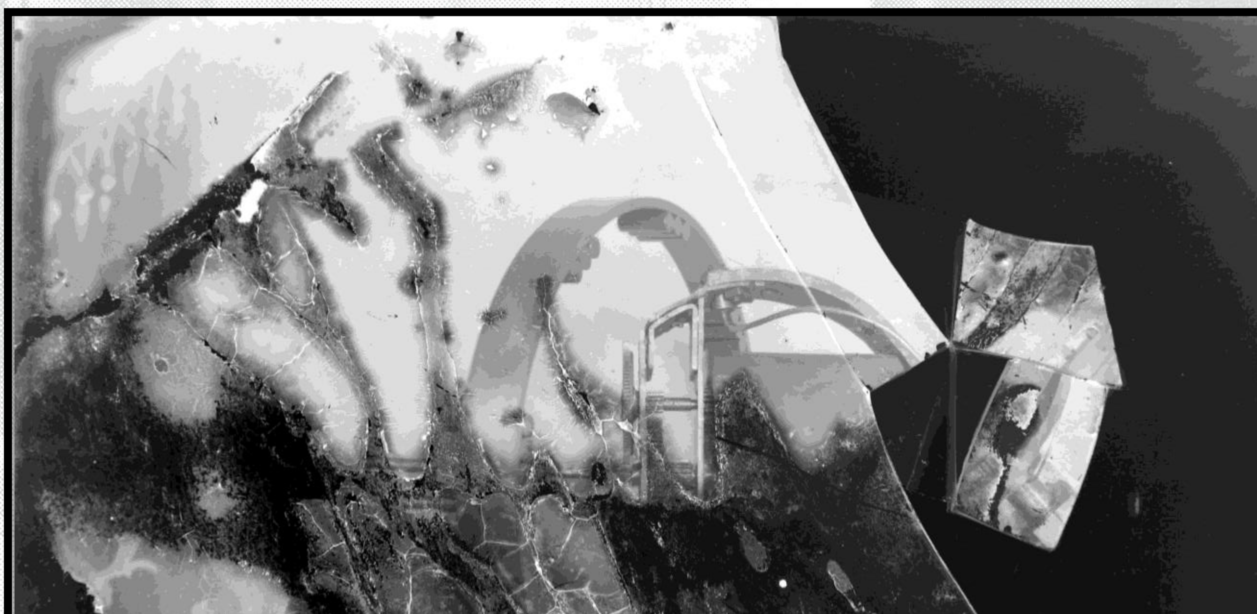
The high frequency currents introduced to the medical profession by Dr. Strong in 1896 are not true electrical currents, but are rapid vibrations electrically generated which seem to replace or augment the vital currents generated by the body.

This treatment, in its most modern form, and modified by other applications, is not a stimulant but acts as a general vitalizing agent, and no sense of shock whatever is felt as with ordinary electric currents. It relieves congestion, promotes healing and alleviates pain. Impaired vitality, due either to age or overwork, is absolutely benefited by this method, and the whole nervous system is tuned up. In throat troubles of an inflammatory, nervous, or reflex nature, and particularly where the bodily force or vigor has been weakened by vocal abuse or bad training, it is of incalculable value. In fact, it is the latest scientific word in this field of research.

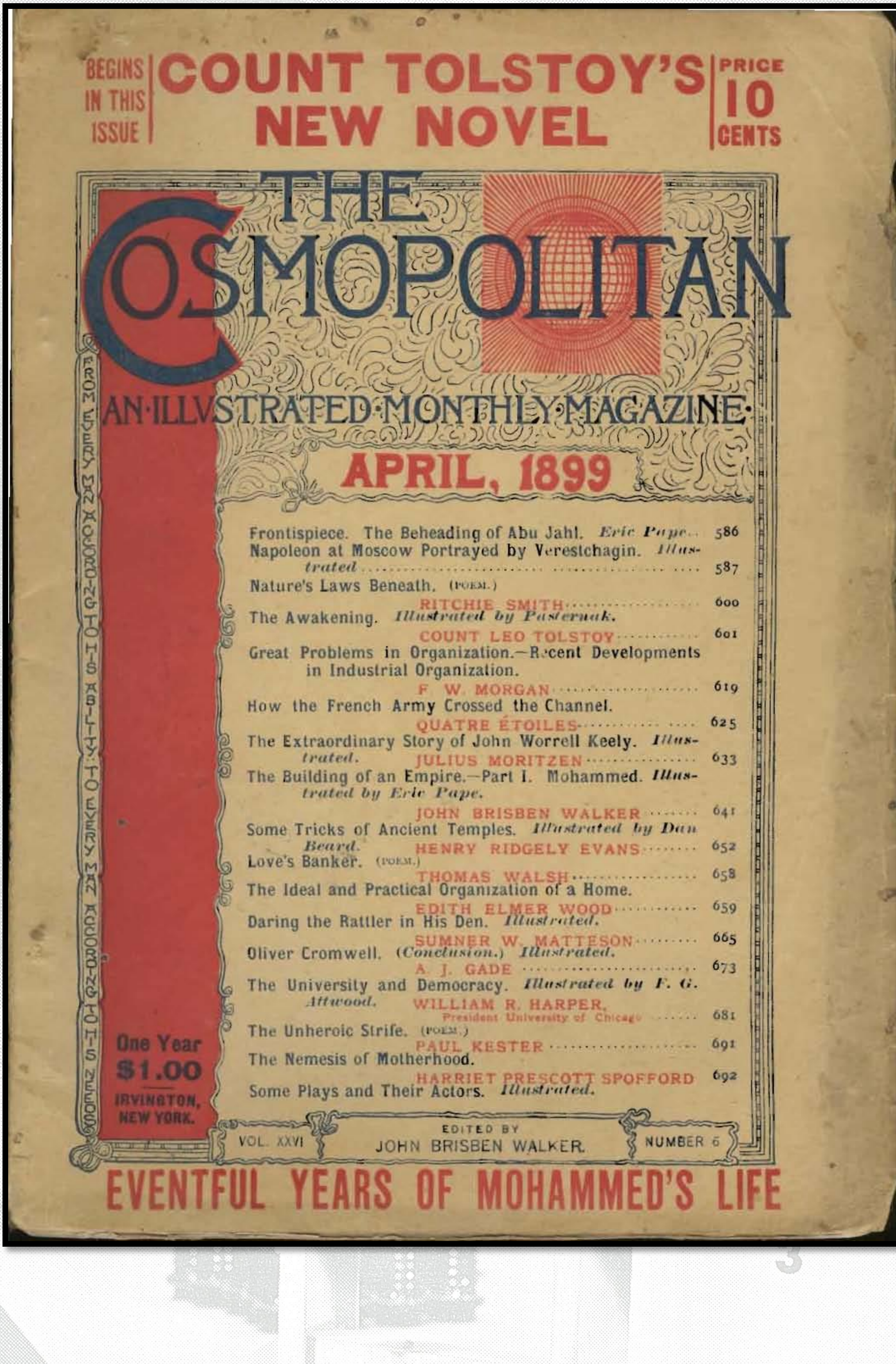
Treatments may be had either by Dr. Strong personally, or by trained assistants under his direct supervision, according to the nature or seriousness of the case.

Appointments and terms upon application.





Original glass plate photos of the Keely Motor, found in Kinraide's home. The second photo shows the windup spring-wound motor and air-brake used to operate the motor.



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COUNT TOLSTOY'S NEW NOVEL

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THE COSMOPOLITAN

AN·ILLVSTRATED·MONTHLY·MAGAZINE·

APRIL, 1899

FROM EVERY MAN ACCORDING TO HIS ABILITY: TO EVERY MAN ACCORDING TO HIS NEEDS

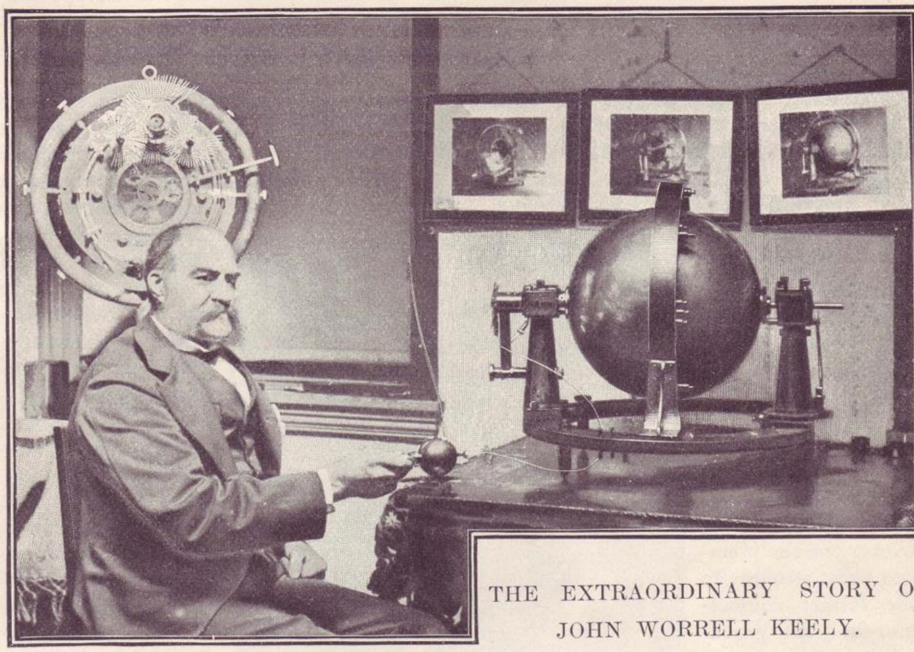
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VOL. XXVI — EDITED BY JOHN BRISBEN WALKER — NUMBER 6

EVENTFUL YEARS OF MOHAMMED'S LIFE



THE EXTRAORDINARY STORY OF JOHN WORRELL KEELY.

BY JULIUS MORITZEN.

PARADOXICAL as it may seem, a century which has seen a Fulton struggle with an unbelieving public, a Morse bringing commercial value to bear on the electric force, has witnessed also a rainbow-chasing multitude whose greed for gain made everything seem plausible—provided the "genius" at the helm had the magnetic strategy, necessary as well to his own sustenance and compensation. The passing of John Worrell Keely, whose recent death came as a crushing blow to those with faith strong enough to endow a tuning-fork or a harmonica with mechanical powers equal to a Niagara, has removed a character as unique as he was puzzling. And yet in his particular case the offspring of his brain did not even attain to the dignity of a patent office applicant. Nevertheless, millions of money sprang to the assistance of the Keely motor project when in the zenith of its quarter-of-a-century existence. Coffers, double-barred to rational undertakings, unlocked instantly at the sound of a phraseology, incomprehensible as it was beguiling.

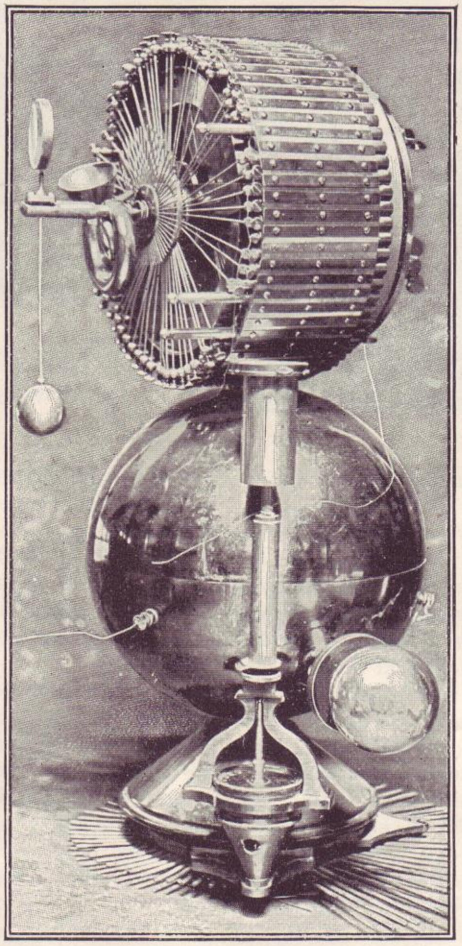
The specter of the Keely motor stalks yet abroad. The death of its maker; the exposures and contradictions; the opinions of well-known men of science; the clinging to straws by those unwilling to admit financial loss—all the swift following incidents in one of the most remarkable transactions the world has ever known—conspire to a lease of notoriety good for many days.

John Worrell Keely was, in truth, a genius. His masterful capacity for keeping some of the world's greatest scientists a-guessing; his command of capital, unlimited at times, with which to carry on his "researches"; his letting it remain for the grave only to tell the secret he did not hold—this, and more, required a brain quite out of the ordinary, and an eye with the cobra's hypnotic charm. Nothing demonstrates more conclusively this overpowering personality of his than the lapse of time, from November 10, 1874—when, in the presence of a dozen well-known Philadelphians, his "vibratory generator" was first exhibited—to the yesterday when Keely stood before another great scientific gathering and "explained" something that was never to be explained. Now, with one fell blow the scythe of death

has cut down the maker and his model. As a result, perhaps, another life went out of its earthly sphere as well. For that Mrs. Bloomfield Moore was heart and soul in the Keely project, the words of Henry Dam, the eminent scientific writer, testify, when he said, shortly after the death, that he had felt intuitively that when Keely died Mrs. Moore would not long survive.

It matters not a great deal what was the agency employed by Keely when in the act of demonstrating his "hydro-pneumatic-pulsating-vacue engine." Was it compressed air, hydraulic power or electricity? The recent exposures of trickery on the premises point strongly to the former conjecture, but the probability is that the exact modus operandi will never be absolutely established.

Bringing the history of the Keely transactions down to the latest developments, the removal of the machinery from the premises occupied by the "inventor" stirred up matters as its remaining could never have accomplished. In the safekeeping of a friend of Keely's, in Boston, the motor's future is as obscure as if it had never been contemplated by its erstwhile maker. But the scenes enacted at the vacated workshop; the exposures; the controversies; the violent persistency with which the investors still cling to probabilities that do not seem even possibilities when viewed from an impartial standpoint; the discovery of the hidden tubing, which came about immediately following the removal of the motor—all this has furnished experts an opportunity for advancing theories that nevertheless do not explain everything it is desirable to have explained.



THE TRANSMITTER.

When Clarence B. Moore, the son of the late Mrs. Bloomfield Moore, came to the realization that the memory of his mother was linked too closely with her interest in the Keely project, to which he had persistently been an antagonist, he resolved that now or never was the hour for exposing the trickery which he was convinced lay at the bottom of the thing. Keely's house was rented and investigations were begun. Leading Philadelphian scientists assisted in the work, and the first discovery came in the shape of an immense steel globe. Almost covered with dirt and rubbish, it was held down in the earth of the cellar by heavy beams. When relieved of its incumbrance, the sphere was lifted out of its resting-place, and subsequently was found to weigh more than three tons. On the top of the globe a hole was discovered and, screw-threaded, the cavity gave a wider diameter the farther penetrated.

Immediately near the sphere was found an iron pipe which led for a distance of more than fifteen feet into the space under the front room. Here was discovered a pit lined with wood and covered by a trap-door. Fresh ashes gave evidence of a careful demolition of material not thought valuable enough for removal, and yet necessary to have out of the way. In these ashes, however, were found short sec-

tions of what at first was considered to be wire, but subsequently proved to be brass tubing. A large amount of glass tubes was likewise found in the debris. The fragments left behind gave striking evidence of the care exercised in removing the Keely motor machinery from its home.

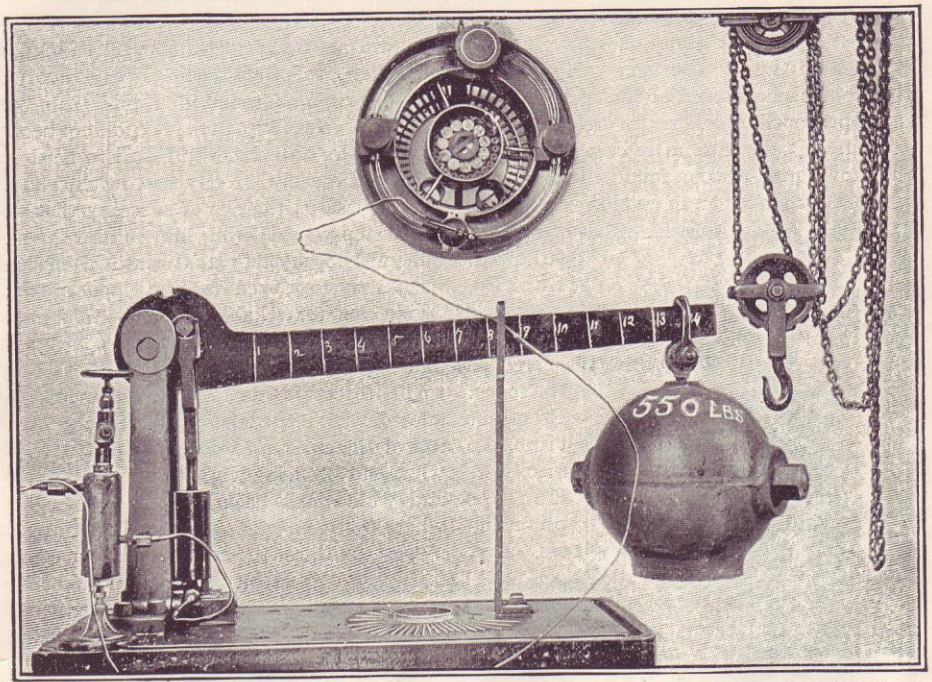
The next day, still greater results rewarded the searchers of the premises. The room in the rear was curiously raised above the others, and this was the apartment in which Keely conducted all those experiments which had puzzled the world until his death.

When the floor was torn up, the revelation was complete. Through the joists, in holes specially cut for the purpose, ran a short brass tube. Other tubes were discovered also, and the whole went to show that the motor had been connected here with the spherical contrivance in the cellar.

In the presence of Prof. Arthur W. Goodspeed, professor of physics at the University of Pennsylvania; Prof. Carl Hering, one of the most eminent electrical engineers in the country; Prof. Lightner Witmer, professor of experimental psychology at the University of Pennsylvania, and Mr. Moore, who had the investigation in charge, the nature of what had been laid bare now came in for earnest consideration. It was determined beyond a doubt that the tubing, and the spherical reservoir found in the cellar, stood conclusively for the argument that compressed air might easily have accomplished all that had been demonstrated so mysteriously by Keely.

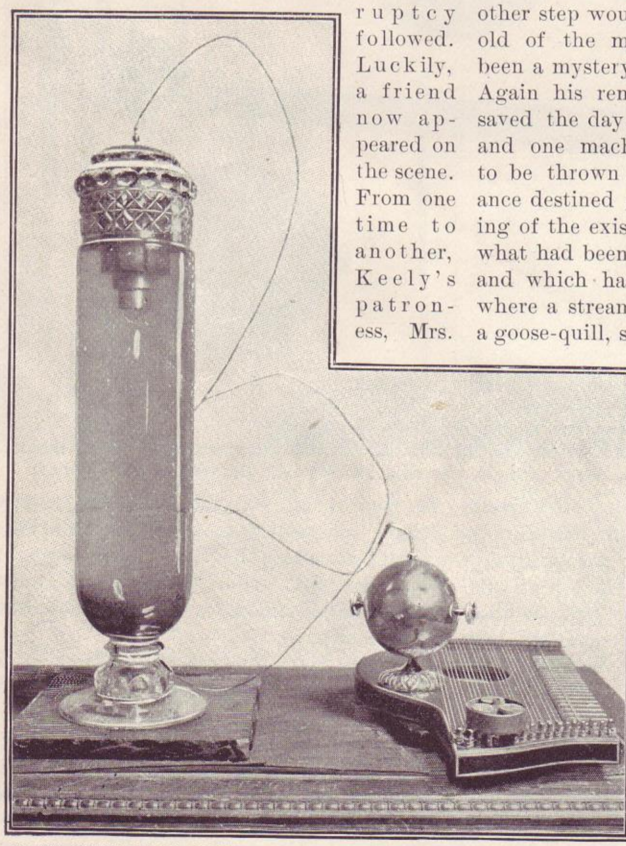
But before entering upon the more detailed account of what came of the exposure, it becomes necessary to revert to the year 1872, the year when the Keely Motor Company was organized, and the enthusiasm anent the "new force" brought into the fold men whose very names at that period stood for common sense and perspicacity.

At the Fifth Avenue Hotel, New York city, a meeting was held, presided over by Edward B. Collier, a lawyer, who in his particular line of patent attorney had from time to time come in contact with inventors struggling for a hearing. The meeting was composed of bankers, merchants, scientists and practical engineers,



"DISINTEGRATOR," AND LEVER FOR MOVING THE ENERGY OF THE "DISINTEGRATED" WATER.

and the result was satisfactory, from a Keely point of view. The project gained substantial assistance. Money was subscribed, and the following day there was placed in the hands of Keely a check for ten thousand dollars; which, to do him justice, he immediately expended for machinery, or material necessary for the construction of his peculiar apparatus. In fact, whatever the vagaries of the man, however much his ideas may have been beyond the limit of common sense, that Keely spent the money which he obtained in experimental investigations cannot be denied even by the most strenuous of his opponents at that time or now. Small consolation this, to the many who fell victims to the smoothness of his speech or the incomprehensible language which he employed. At any rate, after being launched, the motor project soon found itself in deep water. Funds began to get low, and bankruptcy followed. Luckily, a friend now appeared on the scene. From one time to another, Keely's patroness, Mrs. Bloomfield Moore, who was left the executrix of her husband's will, advanced the "inventor" large sums out of the fortune accruing to her from the estate. Now and then a halt was called, to be sure, but the persuasiveness of the "inventor" would make her rally to his assistance once more, and another lease of life would be accorded to the motor.



GLASS CONTAINING WEIGHT WHICH KEELY CLAIMED COULD BE MOVED UP OR DOWN BY STRIKING THE ZITHER STRINGS

A great public exhibition was given in Philadelphia, but while enthusiasm ran riot among a certain clique, skeptics were plenty and the persistency with which Keely would refuse to admit any one into his secret caused a suspicion—which, nevertheless, did not prevent a famous Philadelphia physician from advancing his individual check for ten thousand dollars. This was in 1881. In 1890 the stockholders began to grumble, and something had to be done to save the cause. Keely had just declared that he was on the eve of success; that another step would bring him to the threshold of the mystery that until then had been a mystery even to him, he admitted. Again his remarkable force of character saved the day. The work was continued, and one machine followed another, only to be thrown aside for some new contrivance destined to assist in the revolutionizing of the existing order of things. As to what had been known as the "generator," and which had been part of a bath-tub, where a stream of water, passing through a goose-quill, set the contrivance in motion, the more significant name of "liberator" was now bestowed on the machine. A peculiar feature of the "liberator" was a series of tuning-forks, with the vibrations of which Keely claimed to disintegrate air and release an etheric force capable of rivaling a cyclone in strength if properly utilized and applied. In explanation of what one visitor saw upon one occasion, this individual said that a pint of water poured into a cylinder seemed to work great wonders. The gage showed a pressure of more than fifty thou-

sand pounds to the square inch. Great ropes were torn apart, iron bars broken in two or twisted out of shape, bullets discharged through twelve-inch planks, by a force which could not be determined.

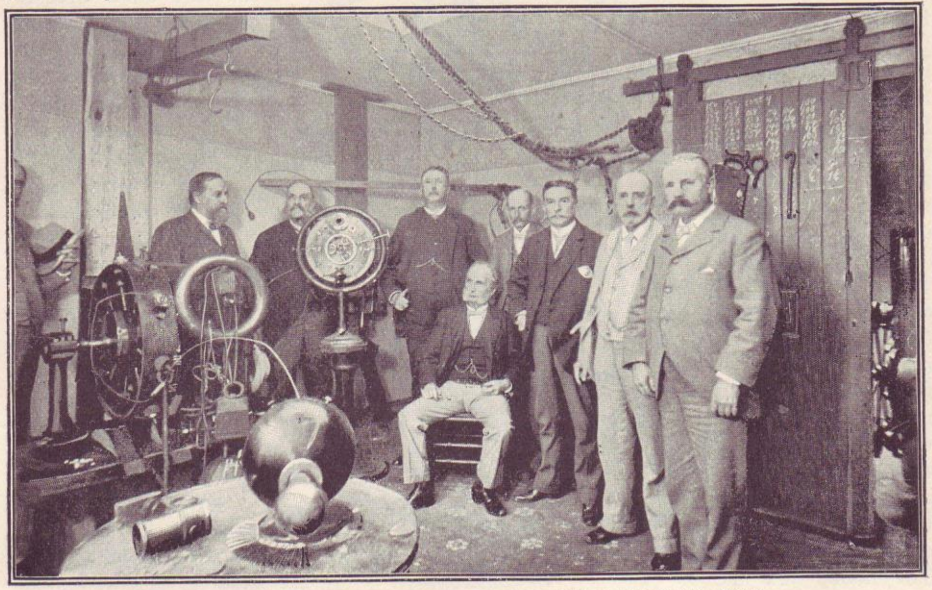
In the glory of his exuberance, Keely now declared that with one quart of water he would be able to send a train of cars from Philadelphia to San Francisco, and that to propel a steamship from New York to Liverpool and return, would require just about one gallon of the same.

It was worth almost the price of falling victim to hear Keely at the time theorize, expostulate where it became necessary, and survey his audience with one of those superior glances which meant to illustrate that he half pitied those who failed to understand his vocabulary. In one respect he was scientific in his procedure of explanation, and in other respects he was quite the reverse. Unquestionably he had read considerably on the subject of locomotion and kindred matters, which might stand him in good stead. But when it came to "molecular vibration," "sympathetic equilibrium," "oscillation of the atom," "etheric disintegration," and a thousand and one similar terms for his motor force, the average mind found its receptive powers hardly equal to the occasion. Then it was that the friends of the motor showed their value to the man who had brought the "invention" into the world. No matter how complicated the phraseology, they would allow for the possibilities in store.

Keely's excuse for not allowing any one into his secret, was based upon the commercial value, which he claimed he desired to have unimpaired for the benefit of the stockholders. It surely would not do to reveal a secret that might prove its own financial defeat, he argued, with emphatic reverence for his own invention, and for the glory and gain in store for those willing to abide their time.

The personality of John Worrell Keely was replete with the charm of heartiness. His was the secret of the promoter's art. He had the insight necessary to the man of affairs, minus that quality of subjection which tells it is time to cease before it is too late. And when considered in this connection, that no one was ever taken absolutely into his confidence, it still remains a mystery how his following continued almost the identical one that stood by him from the conception of the scheme to his death, and after.

When at work in his laboratory, coatless, his grimy hands exhibiting labor's hallmark, Keely looked the personification of the master-craftsman, anxious to wring from the regions of the attainable the

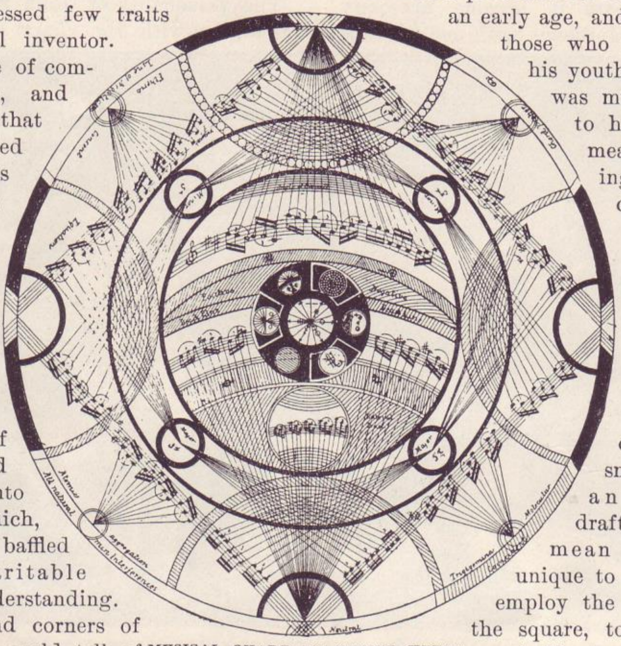


KEELY AND BOARD OF DIRECTORS OF THE KEELY MOTOR COMPANY.

secrets those regions might contain. But when it came to the demonstrating feature, the séance consequent to such exhibitions as once in a while were required, then credulity had to step to the front and make room, as an advance-guard, for the true disciples who stood ready to believe, even sometimes against their own convictions. And when his benefactress implored him to let such men as Mr. Edison into the secret as an evidence that there was no humbug, Keely knew what was best for him, and treated the advice as not worthy of consideration.

Keely possessed few traits of the typical inventor. He lived a life of comparative ease, and the opulence that he displayed led the suspicious to believe that things were not as they ought to be.

And so in that Philadelphia laboratory this man built theories out of metal, and turned metal into theories which, undoubtedly, baffled his own, charitable enough, understanding. The nooks and corners of his workshop could tell of hours spent in chasing the elusive force—provided Keely had been his own worst enemy, and attempted something which he really expected to attain. But it is here that the most momentous question comes to the fore. If he really did believe in his own theories, the discoveries which have been made defy that proposition. And if he was a charlatan, his career will prove one of the most stupendous impositions ever practised by man.



MUSICAL CHART BY WHICH KEELY CLAIMED TO HAVE DISCOVERED HIS "ETHERIC" FORCE.

The scientific nomenclature employed by Keely would have necessitated the reconstruction of the latest dictionary to cover his terms and sentences. If his dreams had come true, "etheric disintegration," "quadruple negative harmonics," "atomic triplets," and the like, would have become part of the teachings in a new curriculum of its kind. But fate decreed otherwise. The "miracle" produced by the drawing of a bow across a string, whereby he claimed to harness or release the force of air and water, the "miracle" of controlling the elements, ceased to exist when he passed away.

Keely's education had been limited to a degree. A carpenter by choice of trade, he had a penchant for mechanics from an early age, and it is said by those who knew him in his youth that his ear was musical enough to have been the means of placing him in the conductor's chair of a small orchestra, at one time. But while those curious musical charts which he drew, with no small skill for an amateur draftsman, may mean something unique to the men who employ the compass and the square, to others they merely illustrated a trend of mind into a domain where mortal should not venture.

It should not be forgotten that Keely predicted that the flying-machine, for which the century has been waiting, would come to pass the moment his motor stood completed. And in the same way he asserted that his pneumatic gun was the one and only instrument of its kind for governments to make use of—as soon as the motor power he had in mind had been produced.

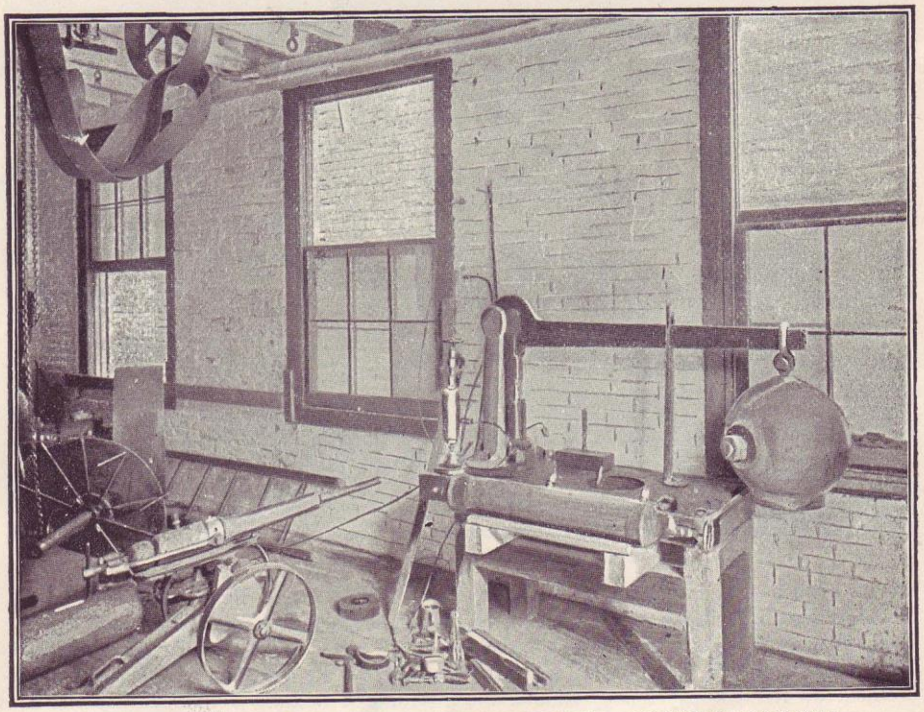
The construction of the motor plant was nearly all his own doing. Composed of the motor proper, and the transmitter, the machine rested on a heavy brass base. Here, too, was a hollow brass sphere or ball.

Between the engine and the transmitter ran a series of wires, and along the base of the transmitter an array of steel rods bristled like so many fixed bayonets ready to repulse the attacks of the incredulous. These steel rods were responsive to the touch, and compared to the ordinary musical scale, which is subject to the tuning-fork.

The interior of the globe almost defied description, but out of the complex mass brass tubes and adhesive plates stood prominently. This was the shifting resonator, as Keely termed it. The tubes and plates took up the vibratory sound and carried it along with rapidity. Of these vibrations there were seven distinct kinds, said Keely, and each of these seven capable of infinitesimal division.

The motor itself consisted of a heavy iron hoop, placed firmly on the plate. Within this hoop ran a drum with eight spokes. When it was once in operation, the movements of the drum were exceedingly rapid and did not fail to impress. Taken in connection with Keely's simultaneous flow of talk about "finding a neutral center," and the like, the performance did not fail to do the work intended. But while the harmonica was supposed to have done the whole thing, starting up the machinery by "etheric force," the exposures recently brought about admit of the supposition that a concealed rubber bulb in the floor was the instrument used. Keely might easily have shut off or released his compressed air by placing his foot on parts of the floor best known to him.

It might be taken for granted that the element still faithful to the apostle's memory are not giving up without a struggle. They aver that the sphere found in the cellar was known by them to be there. One enthusiast goes so far as to say that he knew that Keely, having demonstrated his power in lifting the globe, reversed the experiment and pressed it down in the ground. The heavy beams, which held the sphere in place, rather controvert such a statement.

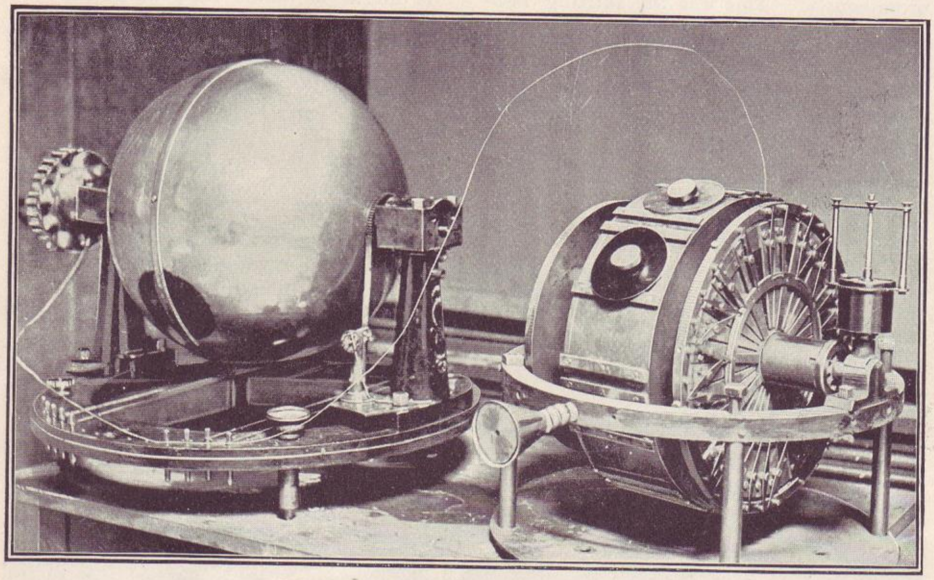


GUN WITH WHICH KEELY EXPERIMENTED AT SANDY HOOK, AND OTHER APPLIANCES.

Since that midnight visit to the dismantled shop of the late John Worrell Keely,

the scientific opinions advanced are of considerable importance, whether bearing upon his motor or his individuality. Renowned professors of physics have stated that they have been convinced for years that the method was compressed air. A medical journal of high standing, in discussing the matter from a psychological point of view, says that rather than make out a case anent Keely it were better to follow the psychological development of his dupes. Continuing, this journal says that the psychology of most inventors usually brings them out too soon rather than too late. "Critics and scientists who may feel inclined to work out the problem of Keely's psychology should remember that insane inventors do not act in any way like Keely," is the exact language of this medical authority. "Their schemes are usually divulged prematurely and they do not hesitate to reveal their wondrous secrets to the world under the protection of a good patent-right. He was not an honest lunatic. He reaped substantial gain from his secrecy, for he ran a joint-stock company."

To all intents and purposes this stock company is still intact, but the action of the Keelyists did not restrain one holder of a hundred shares of stock from disposing of his certificates for a few dollars. The buyer could find a purpose even in the stock paper, however, for it went to the papering of his house. And now, while the machine is in Boston, in the keeping of a friend who is supposed to have known Keely's secret, it behooves to recall the memory of Robert Fulton, through whose alertness it became possible to unearth the perpetual-motion fraud of Redheffer, the impostor who in his time was no less a sphinx than Keely. Only, with the discovery of his imposition Redheffer took to flight. Keely had to die to be discovered.



GLOBE MOTOR AND PROVISIONAL ENGINE.

KEELY REMINISCENCES.

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Noticing in your issue of Dec. 15th, 1893 a review of a book by Mrs. Bloomfield Moore on "Keely and his Discoveries", which book, by the way, I have not seen, it occurred to me that I might contribute a few interesting reminiscences of the early days of the so-called "Keely motor". My remembrance is very clear as to the facts which I shall state.

I lived in Philadelphia during the decade 1870 to 1880, and first heard of Keely about 1875. He had invented a "generator", a "multiplicator" and a "reservoir of force", and according to accounts did a number of very wonderful things with his "vapor". Soon after, I think during the winter of 1875-76, I was invited among others to see an exhibition of the new force at Mr. Keely's laboratory or workshop in Philadelphia. Prof. E. J. Houston was present and about fifty or sixty others, mostly men of business without special scientific or mechanical training.

It would be of little use to go into details of what was done. There was plenty of quasi scientific jargon indulged in by the exhibitor even in those early days. There was nothing said about sympathetic vibrations, or harmonies, as I presume the jargon had not developed to such a pitch of refinement.

The main point with me was to discover whether our exhibitor was self-deceived or not. The opportunity came in a most unexpected way. To show that the generator of the power was empty, Mr. Keely attempted to turn a cock on one end of an iron cylinder and thereby open the cylinder to the air. The cock projecting outward did not turn easily and he seized a pair of gas pliers and --broke it short off near the cylinder. I said to Prof. Houston who stood near, "he must plug that hole." But he did not, although not for a moment did I turn aside, or relax my watchfulness. He dropped the pliers and broken cock and said nothing about it except keep up the jargon of meaningless terms. A few minutes after, on securing the right "indications" consequent on the passage of water through other openings provided therefor, and making a number of passes such as blowing by the breath into still other holes, he got far enough to take off the pressure to show what his vapor could do. To do this he connected a small copper pipe to another cock on the same cylinder, from which he had broken the first without plugging the hole. I concluded naturally that the first was a "dummy" for the purpose of showing that there was no initial pressure in the apparatus.

The "vapor" (compressed air), was passed from the "generator" to the "multiplicator" which was supposed to increase its power enormously. Its passage through the "multiplicator" was uneventful and I suspected it had the function of

a wash bottle which, listened to by Mr. Keely, gave some idea how fast the vapor was being used, as it would not do to let it out too fast or the experiments would come to a sudden termination.

A "globe motor" was shown, and consisted of a globe of copper about eight inches in diameter with hollow trunnions through which the vapor conveying pipe passed to its interior. It got up a speed of 300 or 400 revolutions per minutebut gradually, yet it was said to be impossible to stop it by the hand. It was not to be gotten at by the spectators, and the experiment of stopping it was not made. It rattled about in its bearings while revolving, and I would have undertaken to have stopped it with a slight pressure of my little finger.

The "vapor" from the generator was supposed to have filled a "reservoir of the power" through a copper pipe about eight feet in length of one-sixteenth inch bore in a few seconds to a pressure of about 4000 lbs. (shown by gauge on the reservoir), although the capacity of the reservoir was evidently not far from a cubic foot. And, by the way, the reservoir had near its bottom an ordinary globe valve of about one inch pipe size, opening outward to the air. This valve did not hiss or leak air or water. Can it be possible that the entering vapor tube went direct to the gauge and did not communicate with the interior of the reservoir?

The vapor, according to Mr. Keely, condensed at once on falling to 300 lbs. Pressure, yet we were allowed to hear it hiss and even to smell it as it escaped from the end of the pipe, when the gauge showed much less than that pressure. In fact the gague went steadily down toward the conclusion of the "seance" and very gradually indeed when it reached ten or twenty pounds. It smelled like oily air. The handle of a revolver could be seen projecting from the back pocket of the pair of pantoloons worn by the exhibitor on this occasion. Is not that an eccentricity of genius?

I went to another show of this kind a couple of years later but learned nothing more than I had learned to my own complete satisfaction on the first occasion. There were more etheric vaporings and less experiment. Several subsequent invitations were persistently declined.

I saw in 1879 at the shops of I. P. Morris & Co., Philadelphia, a turned globe of steel three feet in diameter with a six inch opening inside, lying in the scrap metal, a discarded bauble of Keely's. Also two heavy hollow cylinders of forged metal with numbrous forged rings shrunk on the outside --section of rings, nearly square about 4 X 4 inches-- diameter somewhat less than two feet. When I saw them the rings were being turned off or removed in a lathe, a rather heavy job, as was also that of getting them on the cylinders originally. "He pays cash, we ask no questions" was the comment of the director of the works, made to me at the time.

Leaving Philadelphia in 1880, my observations ceased. There were exposures even before that of course. Men eminent in science pronounced the vapor simply compressed air. You say "Keely may ~~xx~~ have at first himself believed in sympathetic vibrations, and afterwards he may have led on his dupes on the same line in which he himself had gone wrong". If he ever believed so, it was before the birth of the Keely motor, as I think you may agree after my evidence above given. The fact is nothing was said about sympathetic vibrations when I attended the early exhibitions. The tuneful motor came later, as did many other things connected with this wonderful motor, wonderful in the fact that despite ~~the fact that~~ its having been lubricated with the money of ~~the~~ credulous fools for twenty years, it persistently refuses to move. ~~[illegible]~~ Perhaps its appearance in London may be a sign that it has removed and will move all its belongings there soon.

Feb 2, 2007

Hello

While doing some family history research I ran across your posting of my father's 1916 book "High Frequency Apparatus."

Needless to say, I was totally unaware of you and your activities; we have various family legends regarding the days of his involvement in high frequency apparatus, but few verifiable facts. If you have any information that would improve my knowledge of that period it would be very welcome. Like many people with a past of this sort he was reluctant to share his memories, in spite of pleas from my brother and I.

My Grandfather (and namesake) was a MD in northern New Jersey, who was an early researcher in X-Ray in medicine, and by legend one of the earliest to apply high frequency AC for exciting the X-Ray tube. He died in 1904, leaving my father, at age 15, with an interest in and a knowledge of electrical engineering that led to a career path involving electricity that kept him busy for 35 years.

During the early part of this he went from a 15 year old in New Jersey to Boston, where he had a experimental AC laboratory sufficiently complex to interest MIT in its use to supplement their DC equipment, on to New York City, where he had an applied research laboratory in 1917.

The publishing of the book followed a several year program of publishing a "do it your self" electrical engineering magazine (which reputedly was seminal in the creation of Popular Science magazine). The laboratory and its entire staff was "drafted" into the Chemical Warfare branch of the U. S. Army in 1917 to work on electric furnace production of gas mask raw materials.

This 12 year period of his activity is pretty "gray" so any clues you might have would help.

There is not much chance of my getting to Florida, but I would love to see the museum. As a kid I did play with spark coils, and was collecting parts for a Van de Graf generator that never approached completion. Its in the genes, tho.

KR

Tom Curtis

Feb 3, 2007

Hello Jeff

This IS exciting isn't it?

The earliest photos of my father I have will probably be from the early or mid 20's when he had relocated to Los Angeles CA after his army experience. By this time he was building a business manufacturing custom refractory items, using electric furnaces to create the "new" synthetic compounds his business was built on. I will need to dig into the archives to find a picture to send, when I get a chance.

A 1916/1818 source you might stand a chance of finding through other research means: I remember as a kid seeing a page from a old brown rotogravure newspaper insert, most likely from the New York Times, of a page of pictures of the "Young engineers that are helping the war effort." On this page Dad was pictured along with Edison, Marconi, Tesla and some others. I'm really not sure of just who was on it, but Dad was in some pretty important company. As I remember Dad's picture was somewhat smaller than Edison's but it was there!

Book: I have never seen the first edition so I'm glad to have your efforts. I do have a copy of the 1920 Second Edition, edited by Raymond F. Yates. According to the second edition preface, the only thing Yates did was to add some of the pertinent 1917 magazine articles and delete the vendor source material, since the Curtis Engineering Laboratory had disappeared. (Dad was definitely not a fan of Yates, the publisher pushed him down Dad's throat for the new edition, since Dad was off busy winning the war).

Magazines: I have a small collection of the "Everyday Mechanics" magazine which morphed into "Everyday Engineering" between Vol. 2 No 5 and Vol. 2 No 6, not a complete set (12 out of the 18 published). I have duplicates of Vol. 2 No. 1 and Vol. 2 No. 2, which I would like to send to you for your museum. Where should I send them?

Equipment: I have no clue where Grandfather Curtis got the HF equipment for his X-Ray work. Seems a stretch that a country doctor could be working from scratch; experimenters were producing terrible radiation burns on themselves and on patients until someone stumbled on the fact that HF generated X-rays were "soft" and less likely to burn (different frequency?); Dad told us that his father made the first picture through an arm that didn't kill the patient.

I don't know how or why Dad got to Boston after his father died. It must have been business related (no family up there); were the equipment suppliers you mention in Mass, could he have been following the trail of the equipment his father had used?

Contact: The reason I'm not likely to make it to Florida is that I live in Saratoga California (near San Jose, 40 miles south of San Francisco), a long ways away! so we had better count on eMail, phone, or whatever. Phone number is 408 867-3541. Phone contact is probably best in the evening, any except for third Wednesdays and Thursdays when I have scheduled meetings. Any time between 6:30 and 10:30 Pacific time will work. If I don't answer by the 3 rd ring don't let it go to the answer machine unless its critical (save your $).

KR

Tom Curtis

Feb 10, 2007

Hello Jeff

Some good news!!

My brother has located the newspaper page showing TSC's photo along with Edison, etc., in his archives. The date on it is April 29, 1917. Actually what he found is physically not exactly what I remembered (his memory also) but the substance is what we were looking for, so there may be another version that hasn't shown up yet. Any way, as soon as we find a way to reproduce it, I will get a copy to you. The type face used is fairly small and the page is a center spread, it is fairly large in size. It needs to be reproduced same size. This makes the reproduction something of a challenge. I'll keep you advised.

Hope your trip north was successful.

KR

Tom Curtis

Feb 13, 2007

The pictures don't ring any bells. The "walrus" mustache was never his style; a small neatly trimmed "military" style is all I ever remember, from early days til the end. (The earliest picture I remember was probably from the 1916 -18 era)

From what I can see of Ovington's time line I don't think they overlapped significantly. There is a mention of his having worked for Edison- when was this? When was Edison's work with X-Ray, that resulted in the death of his assistant? Remember Edison was primarily a DC man and Dad was always on AC, except for battery operated motors, etc., so "friendly" contact then was unlikely, from what I have heard.

KR

Tom Curtis

Sept 13, 2007

Must be mental telepathy- I've been thinking about writing you for the past few days.

My brother and I have been doing some serious genealogy work on the family for the past few months: he took Mother's side, primarily because My Grandfather was Norwegian and his wife is native Norwegian- should make it a little easier. And I have the Curtis side, mostly because as the oldest boy my Aunt felt it was her duty to fill my head with family legends (many of which my research casts a serious doubt on).

I have a serious gap I need to fill and maybe with your knowledge of the technical developments of that era you might be able to point out some paths to follow. Let me set the scene so you can think about it constructively.

My Grandfather (and namesake) was a country MD in northern New Jersey who still had some ties with Columbia Medical Center in NYC (probably he was a graduate although I have not been able to confirm that as yet. He was an early experimenter with medical X-Ray; some how he got turned on to the use of high frequency AC as an exciting source, which proved to produce a less lethal wavelength than the spark coil commonly used, (no clues as to how this happened, but logic tells me that it probably was through Columbia either directly or in directly).

He died suddenly in December 1904 leaving behind Thomas Stanley, a kid of 14 years, who had probably been privy to the experimental work for several years.

There was some kind of mess in the estate that basically threw my Grandmother and two kids, age 14 and 11, on the street with no money. In the 1900 census they were living with Grandmother's mother, who died a month before my Grandfather, who died intestate; it must have been a bonanza for the lawyers and a shambles for Grandmother (who had been raised "a lady" and probably had not a clue as to how to protect herself).

The little family disappeared; not a sign of them in the 1910 census. Dad used to talk of Grandmother trying to make a living peddling cosmetics based on Grandfather's prescription salves and ointments, of living in boarding houses, etc.

Somehow the 14 year old boy in 1904 turned himself into a recognized expert in building AC equipment, and keeping his mother and sister alive, by the time he was 24 years old in 1914. At least part of this time he was in the Boston/Cambridge area. He talked of having AC equipment that he loaned to MIT because all they had to teach EE's on was DC equipment. It is those 10 years that I need to research and find out just what happened.

I know that by 1915 he was in NYC with a operational research laboratory with a staff. In November 1914 he had established his monthly magazine, had a mailing permit for it and must have been well on his way towards completing the book, which was published by Henley, with a 1916 copyright date.

In his acknowledgements in the book's first edition he specifically mentions Melville Eastham and Clapp-Eastham, who started as Ovington X-Ray people, and were running on their own by 1910. The mention of Eastham as an individual suggests a personal relationship, rather than a company one. So maybe as a 19 or 20 year old he was involved personally somehow with this transition.

I have looked at 1910 census records for New Jersey, New York, and Massachusetts without finding a trace; of course, if they were living in boarding houses it would be easy for them to fall through the cracks. And by the 1920 Census he was through a couple of years in the Army doing research on creating chemical warfare gas mask materials, was married, and was in Los Angeles starting a refractory material manufacturing business (his second field of recognized technical competency).

Can you think of any way to establish anything for those missing years of 1904 to 1914? Are there any published histories of Ovington or anyone else in the X-Ray or high frequency AC equipment fields that might shed a clue?

Any constructive thoughts would be appreciated!

KR
Tom Curtis

Sept 14, 2007

I used your suggestion and searched Mass. census records for Prof Houghton; I think I found him, in Waltham, 1910, listed as a teacher working in a school, age 44, living with a wife and Mother in law, no kids. Still there in 1920 minus the MIL. So maybe he did his articles at home, or maybe in conjunction with his teaching, The census is pretty stingy with the information supplied, but the name including middle initial and profession seems good.

Still no sign of TSC there, I think the boarding house syndrome kills all chances.

I think that if we could find out who supplied his father's x-Ray equipment in 1902 or 03, we might find TSC in 1908 or 09 as an apprentice or junior shop help or engineering trainee, some thing with a boarding house type wage level.

I'm pretty sure that he was in Boston or Cambridge somewhere in that period and it must have been a job or the promise of one that justified the move. Something prompted a move from New Jersey- he still had family there- paternal Grandfather, Aunt and Uncle on that side and several Aunts on the maternal side.

No money would have been an incentive to get out of town, the house they lived in (Maternal Grandmother's) before her death was probably upper crust society of the day. center of town, prominent location, very large, built in cook, coachman. I have seen a picture circa 1932 and it was impressive. According to Dad it all went into the lawyers' pockets. Some day I may get into the Probate records, but that is just curiosity, doesn't prove anything.

Lots of conjecture, too few facts.

KR

Tom

Sept 23, 2007

Just stumbled on something that, you with your knowledge and skills might be able to dig into.

Between April 1916 and September 1917 TSC in New York City published a small monthly technical magazine. Initially this publication was called "Everyday Mechanics," and was published by Everyday Mechanics Co., Inc. In February 1917 the name of the publication was changed to "Everyday Engineering" probably as a result of a law suit by Popular Mechanics magazine (conjecture, based on some published letters to the editor). TSC was listed as Editor and some familiar names appear here and there, like Prof. Wm. C Houghton.

Sometime in late 1917 or early 1918 TSC and his R & D team were "drafted" into the Chemical Warfare Service, U. S. Army, to work on the problems of making gas masks, or rather the electric furnace products needed for the canisters (activated alumina and activated charcoal). He did extended travels in the search for the raw materials for the activated alumina, which eventually led him, after his discharge, to California and his refractory business (products based on aluminum silicates, the byproduct of activated alumina production).

His departure from NYC for the Army ended his interest in electrical engineering "how to do it's" but the magazine evidently survived somehow. The 1920 second edition of his book, in the advertising section, has an ad for the magazine.

I have an incomplete set of the magazines from Volume 1, Number 6 (September 1916) to Volume 3 Number 6 September, 1917). In the preface of the second edition of the book, the Editor, Raymond F. Yates, acknowledges that his total editorial contribution was to add articles from the magazine, on new subjects, to the book.

This morning, on a wild whim, I Googled "Everyday Engineering" and much to my surprise found a web site under that name, dedicated to publishing stories and reprinted ads from popular technical publications of the 1020 era. The first magazine cover they show is the December 1918 issue of Everyday Engineering, which has the same banner typeface and the same general look, including the $.10 price of TSC's last issue. The next one they show is August 1919, which is Volume 7 Number 5 and the price has gone up to $.15. There is no editorial material shown anywhere, just ads for A.C. Gilbert (ErectorSet, and several electrical experimental kits).

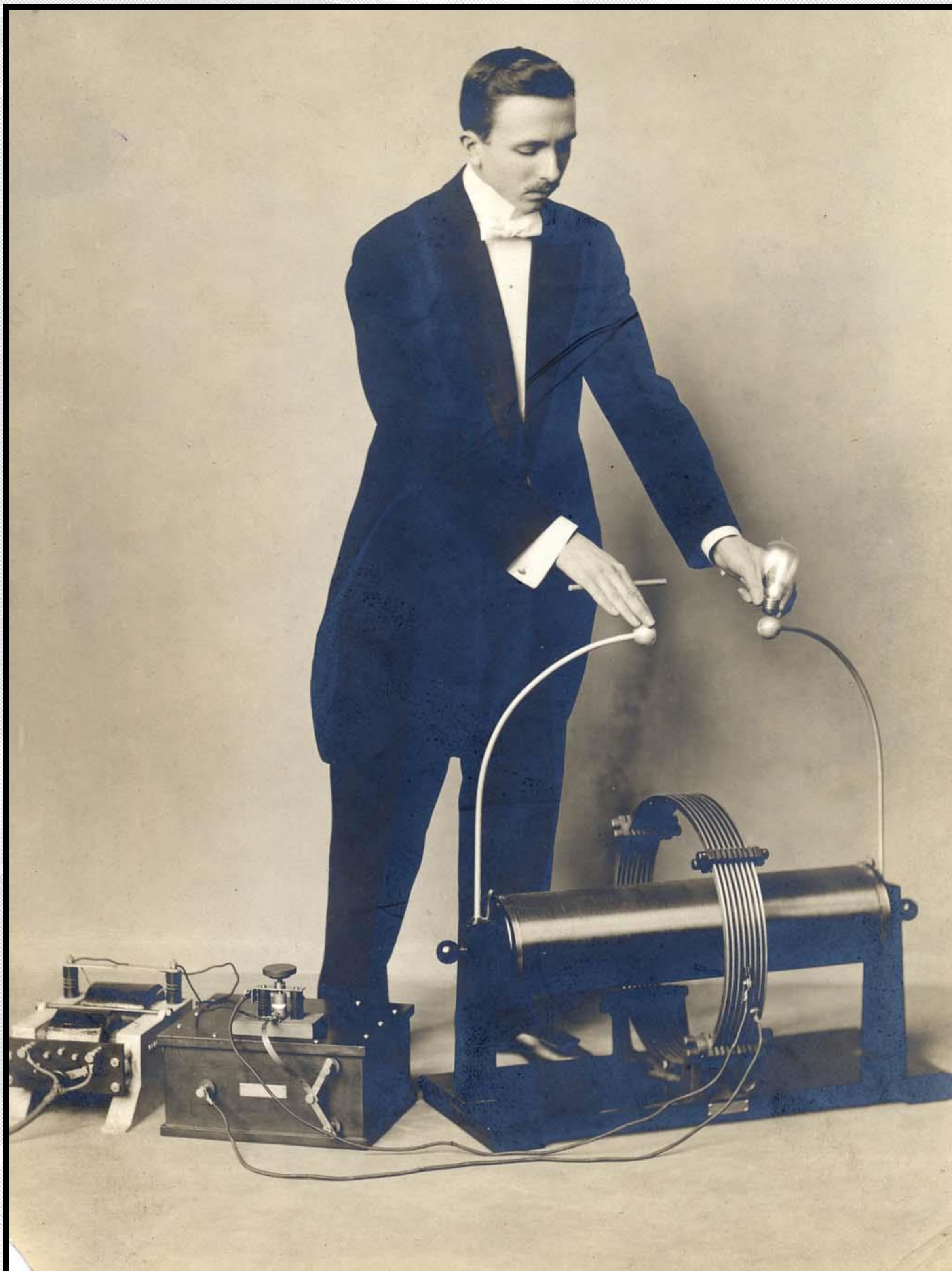
There is no clue to who is posting this material, and no mention of the early history of the publication they feature, at least as far as we are aware of it. Of course I'm still working in the dark as to those missing 10 years and really pretty much in the shadows on the Army service period (the first pass on that has only revealed that the Federal archive had a fire in the 70's that destroyed all Army records from 1912 to 1920, real convenient!!!).

Can you give me a clue on how to get into the originator of this web site. Telling the story of the founding of the magazine might lead to some clues into my blackout period.

KR

Tom

ps your new posting on TSC is GREAT!!



Thomas Stanley Curtis. I could not find any documents between Curtis and Tesla, which is unusual. Curtis lived in New York and as a young man sold components to make Tesla Coils in addition to writing one of the most comprehensive books on Tesla Coil construction, “High Frequency Apparatus”.



One of many replica coils the author has built from books of Thomas Stanley Curtis



Illustrated Sunday Magazine — For April 29, 1917

Useful Service to Uncle Sam

A man whose photograph hasn't been taken since the college glee club days. But this is not his claim to distinction. He designed and built a fleet of five hundred and fifty submarine chasers and is now at work on plans for a new submarine-destroying craft. Around the Bureau of Construction and Repairs of the Navy Department, Henry R. Sutphen is a name which spells Preparedness and Patriotism.

One of the reasons why we are not entirely unprepared. In the prime of life Hudson Maxim went into the explosive business and in a short space of time managed to discover and perfect a lot of things which are invaluable to our country today. He was formerly in the printing and subscription business and is still on the advisory board of the Simplified Spelling League.

The president of a great railroad and chairman of the Advisory Committee on National Defense. Daniel Willard is rigorously pressing arrangements for the coordination of all industrial and commercial resources of the nation. He devotes practically all of his time to the work of mobilizing American industrial resources.

She is directing a movement to organize, register and coordinate the "woman power" of this country. Miss Grace Parker, the Commandant of the National League for Woman's Service has recently returned from England where she was permitted to study the myriad branches of national service being performed by the women of that country.

An actor whose idea of patriotism does not stop with waving the flag. While playing in New York City, Reginald Barlow, an officer in the National Guard, conceived and carried out the idea of organizing the actors, artists and writers into an officers' training corps.

This is the richest young man in the richest city in the world and his work for defense is of the real variety. While Vincent Astor is a member of corporations and clubs almost too numerous to mention on the whole of this page, he is giving all of his time to his country's defense.

He stands for universal service in the United States. He is the president of a great publishing house, and finds time to be a leader in the American Defense Society. Colonel Joseph H. Colt keeps careful tab on everything pertaining to preparedness and tells the public what's what in defense with the aid of newspapers and magazines.

A regular person who needs no introduction to the general public. A pacifist with his back to the wall, Henry Ford has not only offered his [illegible] plants to the Government but his private fortune as well.

This grand young man of seventy is daily giving Uncle Sammy twenty hours of his undivided attention. As a youngster he sold papers instead of attending school, but today he holds honorary degrees from most of the great universities.

Arthur Woods, Commissioner of Police of New York City, who has organized a Home Defense League of fifteen thousand citizens from all walks of life to take over the regular police duties should the occasion demand.

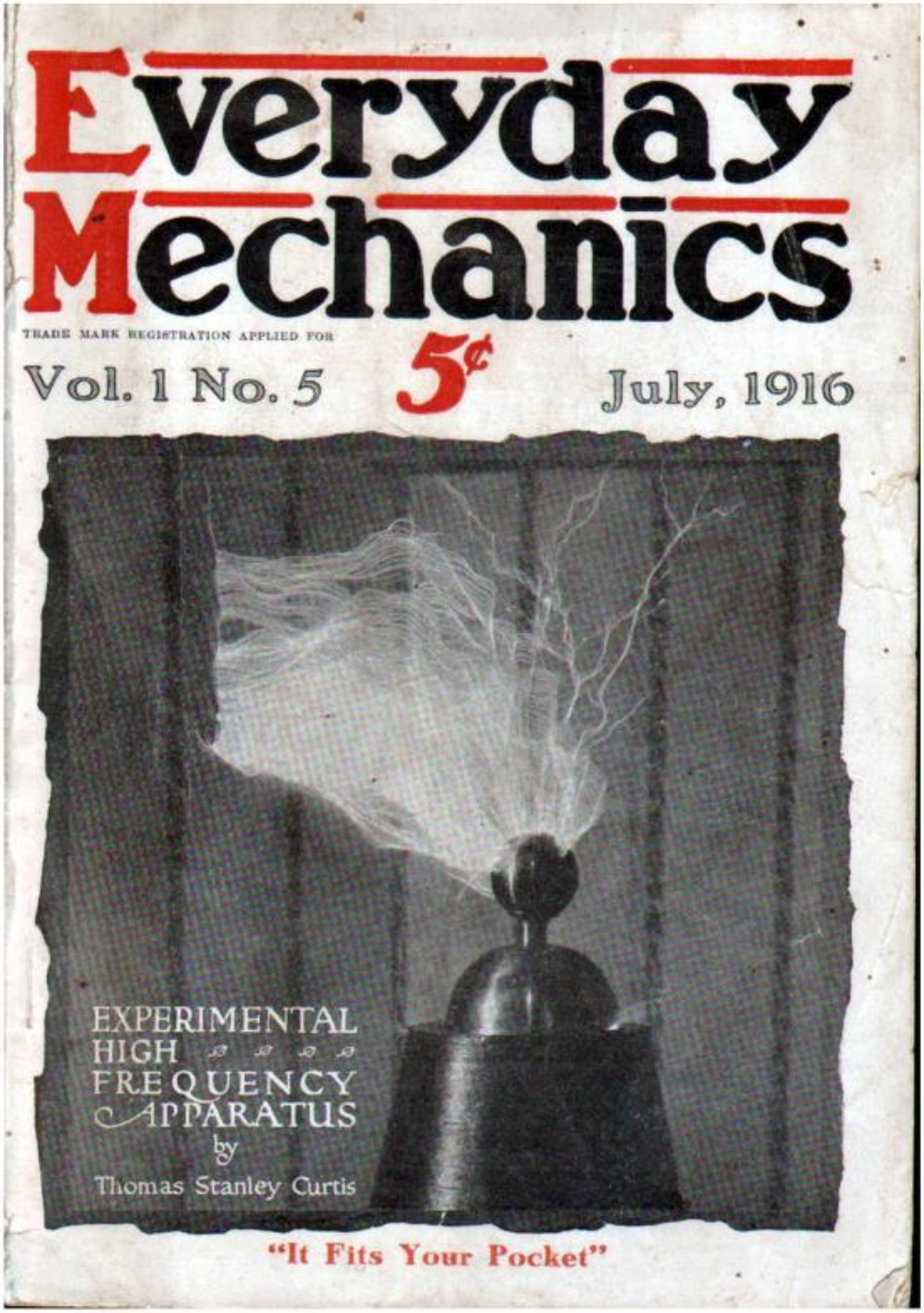
A society woman who is truly patriotic. Mrs. Norman de R. Whitehouse presented the Governor of New York State with a set of resolutions adopted by the New York Women's Suffrage party, offering the services of its members in any capacity during war times.

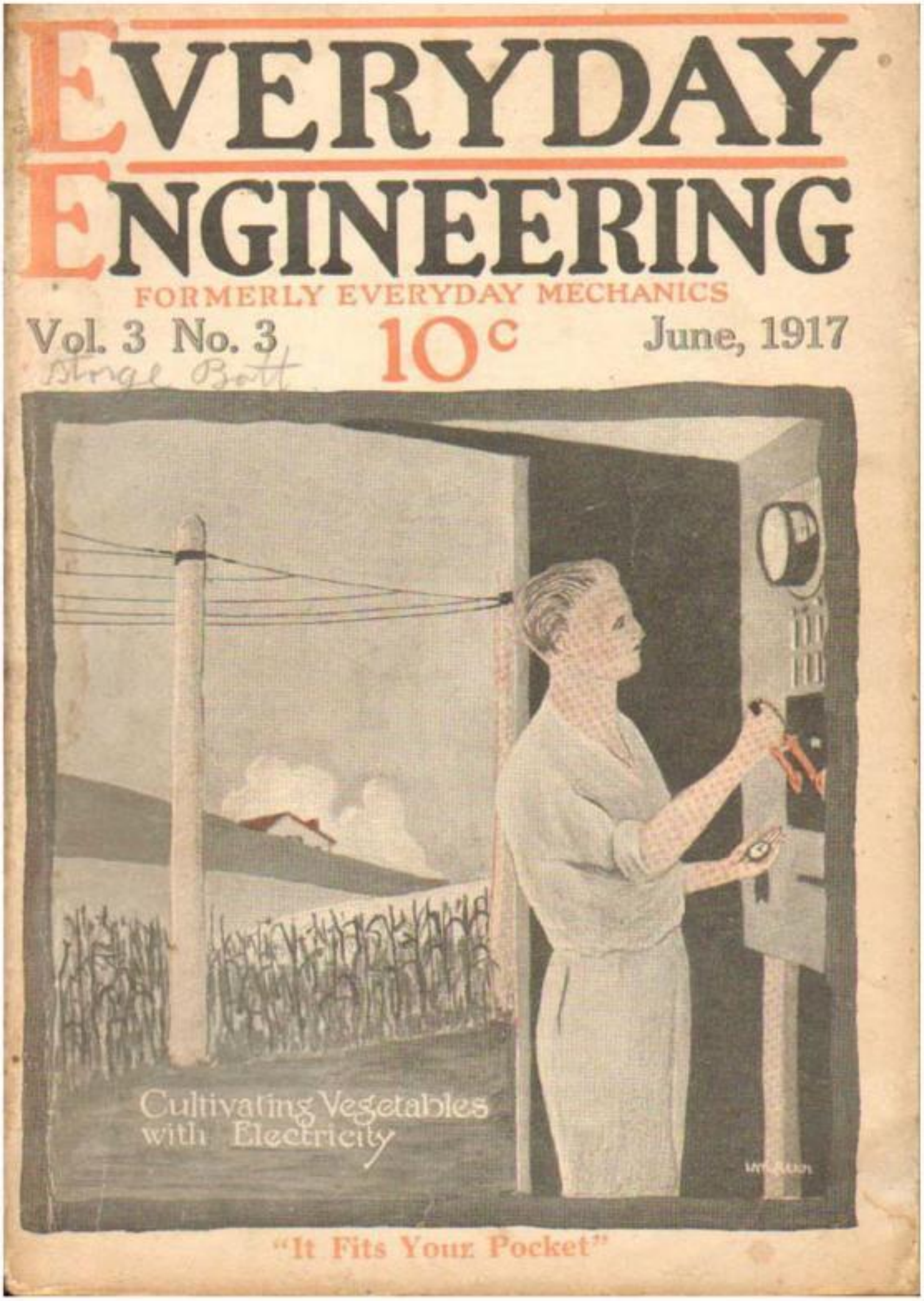
His exploits rival the most lurid detective fiction. He is the chief of a great agency whose ramifications extend all over the world. William J. Burns, the detective and author of many stories which have appeared in this magazine, has been instrumental in running down much of the spy activity in this country.

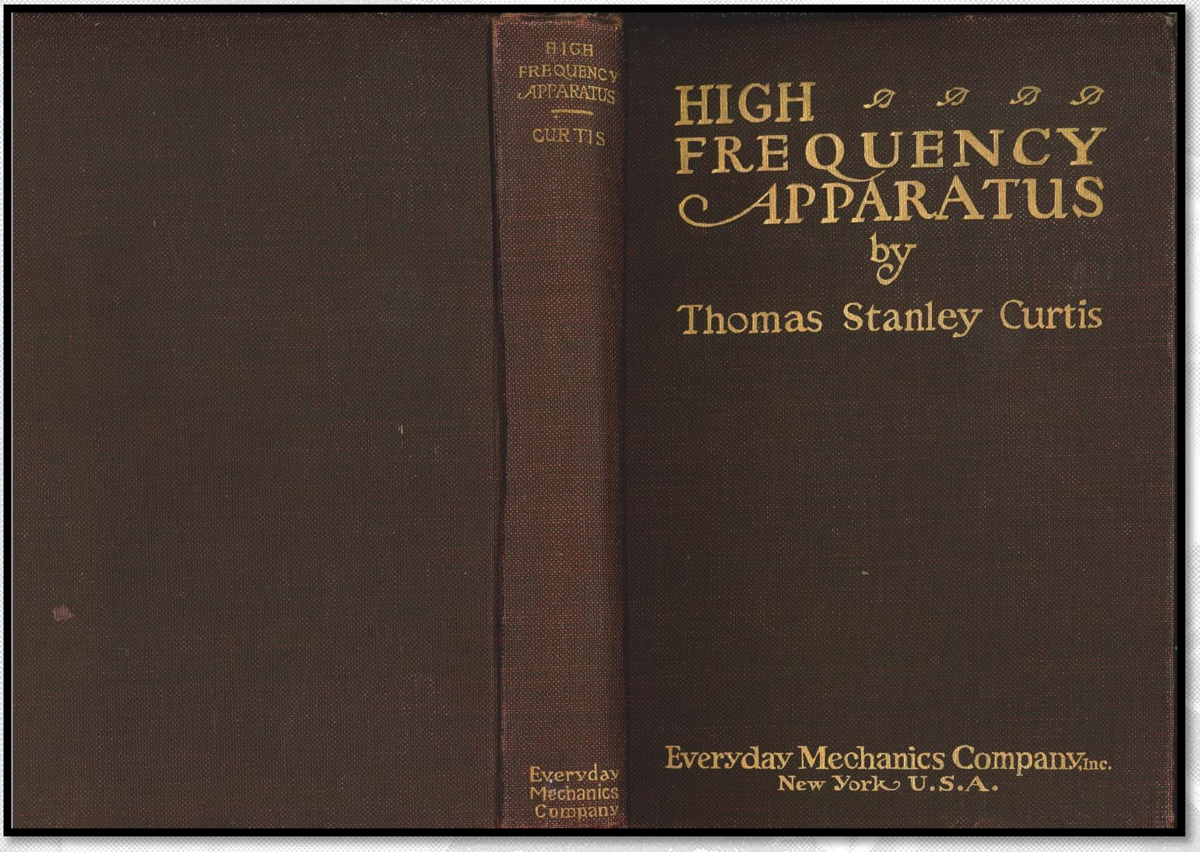
He is the chief of a society which encourages practical science among amateurs. Thomas Stanley Curtis shown with his new radiodynamic submarine.

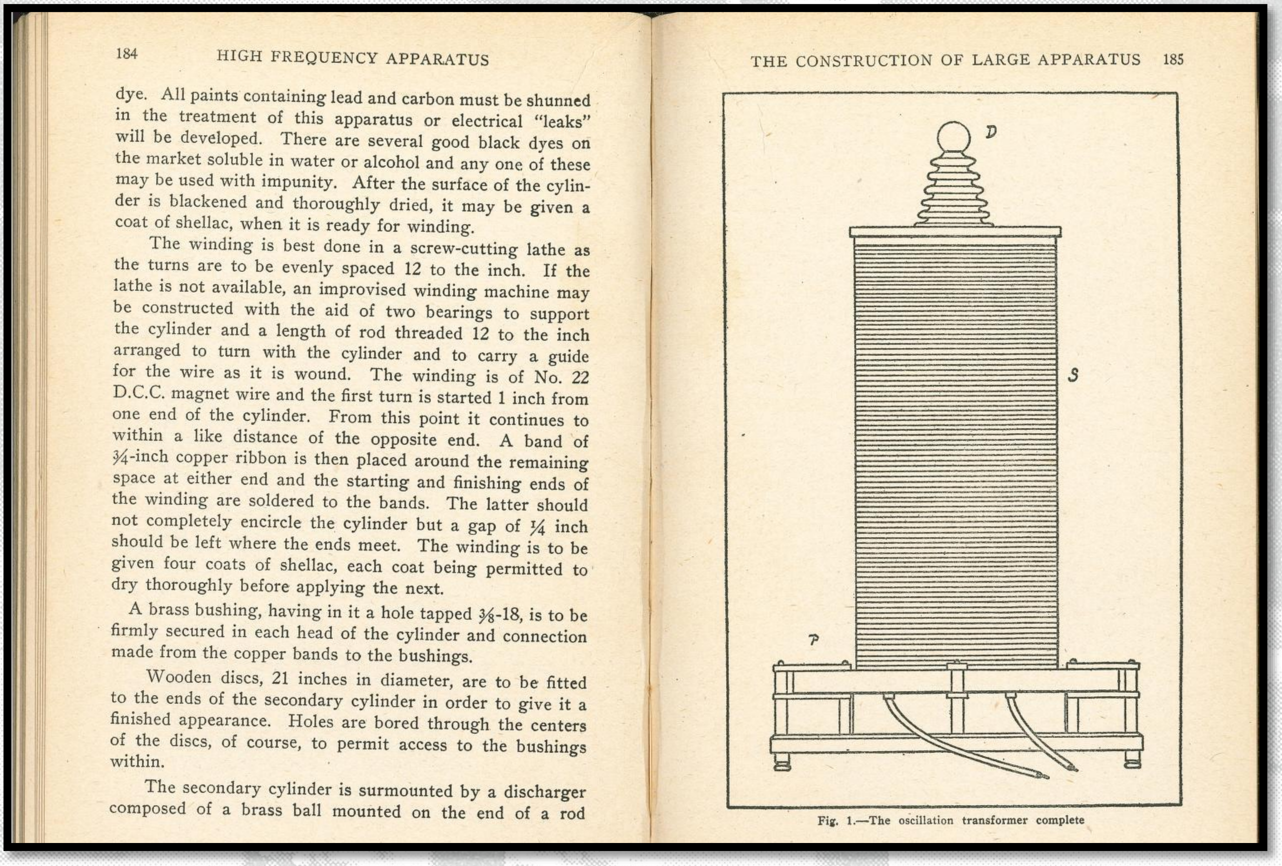


He is the chief of a society which encourages practical science among amateurs. Thomas Stanley Curtis shown with his new radiodynamic submarine.


Everyday Mechanics
TRADE MARK REGISTRATION APPLIED FOR
Vol. 1 No. 5
5¢
July, 1916
EXPERIMENTAL HIGH FREQUENCY APPARATUS
by
Thomas Stanley Curtis
"It Fits Your Pocket"


EVERYDAY ENGINEERING
FORMERLY EVERYDAY MECHANICS
Vol. 3 No. 3
10c
June, 1917
Cultivating Vegetables with Electricity
"It Fits Your Pocket"





184 HIGH FREQUENCY APPARATUS

dye. All paints containing lead and carbon must be shunned in the treatment of this apparatus or electrical "leaks" will be developed. There are several good black dyes on the market soluble in water or alcohol and any one of these may be used with impunity. After the surface of the cylinder is blackened and thoroughly dried, it may be given a coat of shellac, when it is ready for winding.

The winding is best done in a screw-cutting lathe as the turns are to be evenly spaced 12 to the inch. If the lathe is not available, an improvised winding machine may be constructed with the aid of two bearings to support the cylinder and a length of rod threaded 12 to the inch arranged to turn with the cylinder and to carry a guide for the wire as it is wound. The winding is of No. 22 D.C.C. magnet wire and the first turn is started 1 inch from one end of the cylinder. From this point it continues to within a like distance of the opposite end. A band of ¾-inch copper ribbon is then placed around the remaining space at either end and the starting and finishing ends of the winding are soldered to the bands. The latter should not completely encircle the cylinder but a gap of ¼ inch should be left where the ends meet. The winding is to be given four coats of shellac, each coat being permitted to dry thoroughly before applying the next.

A brass bushing, having in it a hole tapped ⅜-18, is to be firmly secured in each head of the cylinder and connection made from the copper bands to the bushings.

Wooden discs, 21 inches in diameter, are to be fitted to the ends of the secondary cylinder in order to give it a finished appearance. Holes are bored through the centers of the discs, of course, to permit access to the bushings within.

The secondary cylinder is surmounted by a discharger composed of a brass ball mounted on the end of a rod

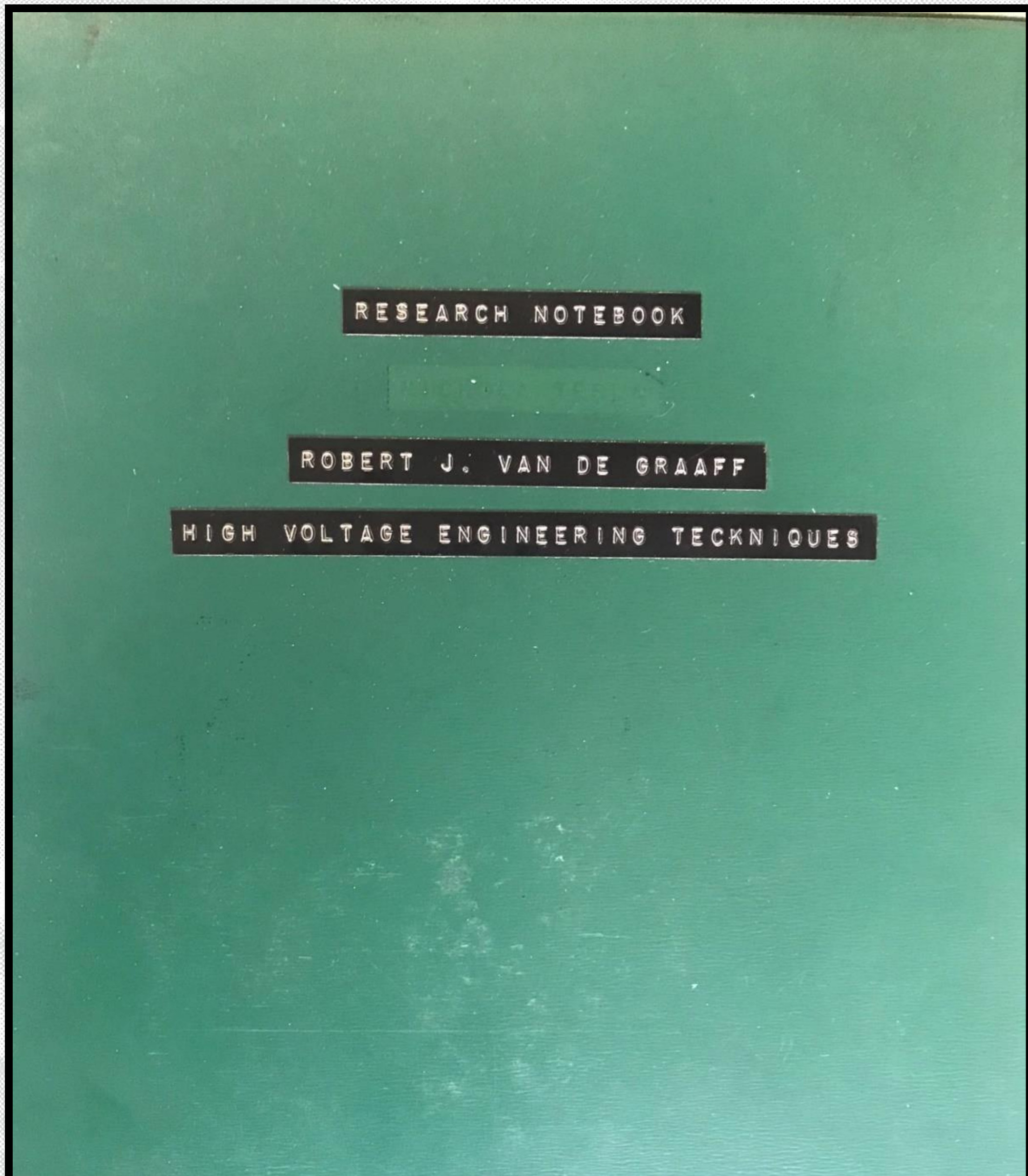
THE CONSTRUCTION OF LARGE APPARATUS 185

D
S
P

Fig. 1.—The oscillation transformer complete



Original stage coil of Thomas Stanley Curtis, found in the basement of Chicago Museum of Science and Industry.
There is also a large bipolar coil for theatrics which is also located in the basement.



William C. (Bill) Wysock was an aerospace engineer who started off life as a recording master. He formed a modern company to manufacture Tesla Coils, Tesla Technology Research (originally Professional Sound Systems, Ultra-High Voltage Division). He was inspired by Tesla as a young boy seeing the Griffith Observatory Tesla Coil. His like came full-circle when he was asked to restore the coil toward the end of his life. He also built two full-size replicas of the coils which were on display at Fry's Electronics and the Mid-America Science Museum. Bill was fortunate to know Kenneth Strickfaden.




THE GRIFFITH OBSERVER
Vol. XXIX, No. 8
August 1965
20 Cents

THE TESLA COIL

Anyone who has watched the Tesla coil in operation at the Griffith Observatory will have noted its spectacular spark resembling, on a small scale, the natural lightning during a thunderstorm. The air acts like an insulator until a certain voltage per foot or potential gradient is exceeded. This corona type of discharge into the air can be seen on a dark night on high voltage transmission lines. As the voltage is increased the coronal streamers become longer, and if this increase continues, the streamers reach the other side of the circuit, or ground, if the circuit is grounded. When this occurs, an arc is established and the current rapidly increases until the source or supply is exhausted or reduced in voltage to a point such that it cannot support the arc.

Millions of visitors have watched the operation of the Tesla coil and some may have wished to know more of its exact functioning. We receive many requests for information about the Tesla coil. We hope this description will answer these questions and anticipate a few that may have been unasked. A description of the Tesla coil was published in the Griffith Observer 17 years ago, but this issue is now out of print. This article will describe the operation as it is today, as some changes have been made in over 28 years of operation.

The name "Tesla coil" is usually applied to all tuned transformers of this type used to produce a very high voltage. Actually the correct name is "Oudin coil" when one end of the coil is connected to the ground. A Tesla coil has the grounded point in the middle and the spark jumps from one end to the other. We have the other half of the coil but did not have room in the museum to install it. The spark is about twice as long with the complete coil, as tested in our shops.

The following description of the apparatus is necessary to guide anyone wishing to build a Tesla coil. One word of caution is appropriate at this point. When using a Tesla coil similar to ours, the voltage and current available from the primary and secondary of the coil is enough to have lethal results, if you come in contact with any of the wires. Extreme caution must be used by you and anyone else who may be around the equipment. Many interesting exhibits have been made of the Tesla coil with less power in the driving transformer. These are not as dangerous.

The 120-volt current is fed to the transformer as shown in Fig. 1 through a line filter, which prevents any feedback of the radio frequencies produced by the apparatus into the electrical lines in the building. Each of the four capacitors has 2 microfarads of capacity and 1000-volt insulation. The two coils are wound on a form 3½ inches in diameter and 12 inches long with 57 turns of No. 12 copper wire. The transformer is a power transformer in a case filled with oil. It is similar to the ones you see on power poles to step the voltage down for your home use. This transformer steps the voltage up and has a special type of winding, which limits the current when the spark gap shorts the high-voltage secondary coil. Neon sign transformers, which are often used for Tesla coils, also have a current-limiting winding, so that it is safe to short the secondary winding. This part of the apparatus is below the floor of the museum and is not visible to our visitors.

The rotary gap has two stationary electrodes and the wheel has 14 copper bars in an insulating disk which turns 1800 revolutions per minute. As each copper bar comes between the stationary electrodes, a spark jumps and this shock excites the primary circuit. The spark is between tungsten disks fastened to the ends of the copper bars. The spacing is about one-sixteenth of an inch, but this is not too im-

THE GRIFFITH OBSERVER
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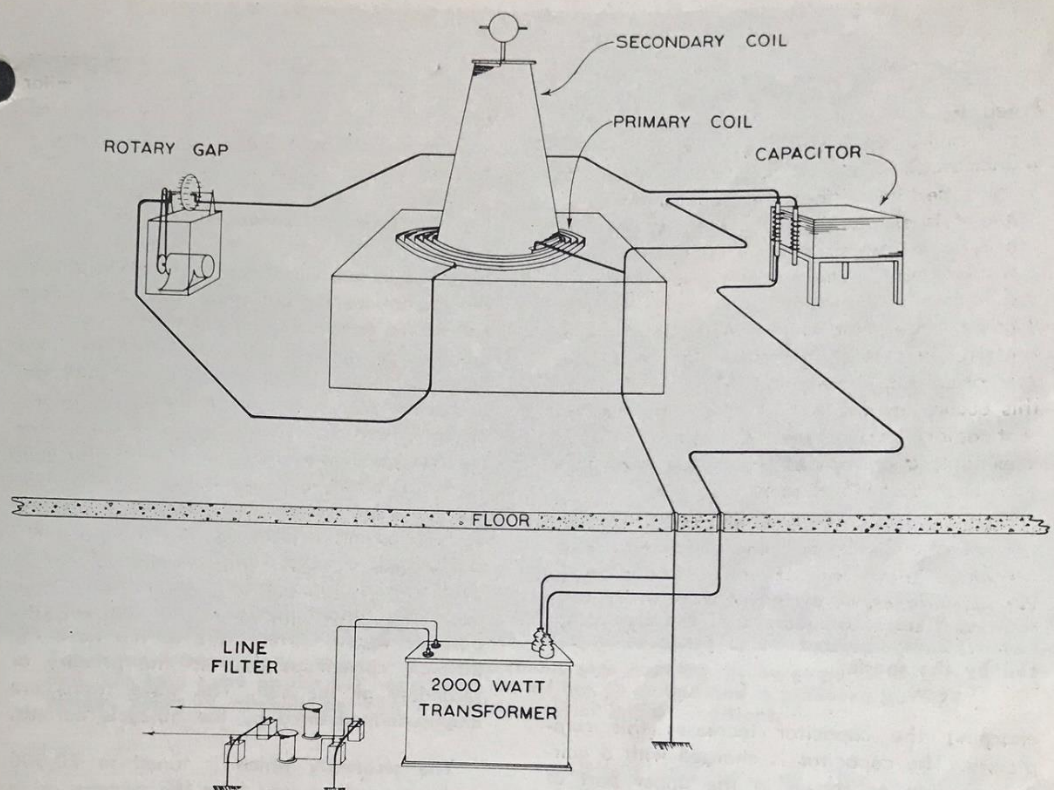


Fig. 1. Diagram of the Tesla coil. The parts shown below the floor are not visible in the museum.

portant except that it must be small enough for the voltage from the power transformer to jump.

The capacitor is made of 30 glass plates 24 inches by 30 inches by ⅜ of an inch thick. The 29 copper plates between the glass are 15 inches by 14 inches by 0.02 inch thick. The glass plates were made ⅜ of an inch thick because the original capacitor had 3/16-inch glass and it was often punctured by the voltage. The primary coil has 5¾ turns of ¾-inch by 3/16-inch rectangular copper bar. It is necessary to make the primary circuit consisting of the rotary gap, the capacitor and primary coil of heavy conductors, as many amperes flow in this resonant circuit and the efficiency would be decreased if the resistance was not very low. We use No. 1 wire to connect these units.

The secondary form is 47 inches high and has a bottom diameter of 36 inches and a top diameter of 18 inches. It is wound with 400 turns of No. 14 copper wire. It is not necessary to make a tapered coil, but it is easier to prevent corona from the top turns of the coil if the diameter is smaller. The 12-inch ball on top is a hollow copper sphere. It prevents excessive corona from the top end of the coil and wires. This would constitute a loss of power. The points on each side concentrate the discharge for our visitors to observe more easily.

The operation of the circuit is quite complex and the use of 60-cycle alternating current for

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GENERAL MANAGER

GRIFFITH OBSERVATORY
AND PLANETARIUM
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LOS ANGELES 90027
664-1192

C. H. CLEMINSHAW, PH.D.
DIRECTOR
LEON HALL
ASSOCIATE DIRECTOR

August 17, 1965

Mr. Bill Wysock
508 W. Lemon Avenue
Arcadia, California

Dear Mr. Wysock:

We used the pancake coil because it was easy to make and allowed the use of adjustible clips to tune the primary circuit. Copper is a soft metal and we used the rolls which are usually used for sheet metal. It was about 1936 when we tested the coils and my memory does not include the exact circuit used. I would suggest if you have uneven operation of the two coils that you try a series hookup instead of parallel hookup as you have now. We did not take any photographs of the two coils operating.

Sincerely,

Leon Hall

Leon Hall
Associate Director

LH:pow

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DEPARTMENT OF RECREATION AND PARKS
WM. FREDERICKSON, JR., GENERAL MANAGER
GRIFFITH OBSERVATORY AND PLANETARIUM
P. O. BOX 27787
LOS ANGELES 90027
664-1192
C. H. CLEMINSHAW, PH.D., DIRECTOR
LEON HALL, ASSOCIATE DIRECTOR

August 5, 1965

Mr. Bill Wysock
509 W. Lemon Avenue
Arcadia, California

Dear Mr. Wysock:

Dr. Cleminshaw has asked me to answer your recent letter.

We are pleased that your photographs have turned out to be satisfactory. The books on Tesla sound interesting. We can translate German and possibly some French but not the other languages.

The calculated capacity of the condenser is 200 micromicrofarads as near as we can tell not knowing exactly the dielectric constant of the glass. This could be measured with greater accuracy with instruments we have at Griffith Observatory but this has not been done. Its exact value is not important to us as we vary the turns in the primary coil for resonance.

We had the two complete secondaries given to us without any primary coils. We constructed two identical primary coils for the two secondary coils. We had them setup side by side in the basement. We then operated them with the transformer we are now using. The transformer has a 110 or 220 volt imput and we are now putting 120 volts across the 220 volt winding. When we tested the two coils at the same time we put 230 volts across the 220 volt primary getting about twice the voltage to charge the capacitors which at that time were Leyden jars. I can assure you that this is true as I personally setup the coils both in the basement and upstairs in the museum.

At the present time one of the secondary coil forms is in the basement. After about fifteen years of operation it was necessary to replace the secondary in use because of breakdown in the winding. We stripped the winding but have not had time as yet to rewind it.

I am enclosing a "Griffith Observer" which describes the "Electrical Discharge in Gases" exhibit. I do not believe an article has been written on the Jacob's Ladder exhibit.

If we can furnish any additional information please feel free to write us again.

Sincerely,

Leon Hall

(PG. 2)

RESULTS OF OPPERATION WITH
THE MILLION-VOLT TESLA COIL

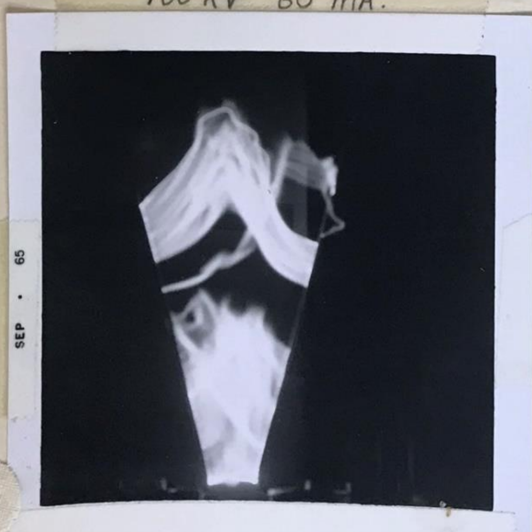
One of the first things Greg and I discovered, is that in order to obtain maximum therdetical output of this coil, we must use materials of the highest quality, the greatest seperation of the individual components between eachother, and heavy conductors in the reasonate circut as many ampers of radio-frequency current flow in this circut. With out heavy conductors in this circut, resistance will cut down greatly on the effinicy of the entire apperatus.

When the forgoing has been secured and all safety requirements are secured, the operation of the apperatus can be commenced. A complete description of the operation and results of experiments carried out with this coil follows herein. Bill Wysoch

"JACOB'S LADDER"

DISCHARGES OF X-RAY TRANSFORMER

100 KV 60 MA.



2 ONE-SECOND EXPOSURES

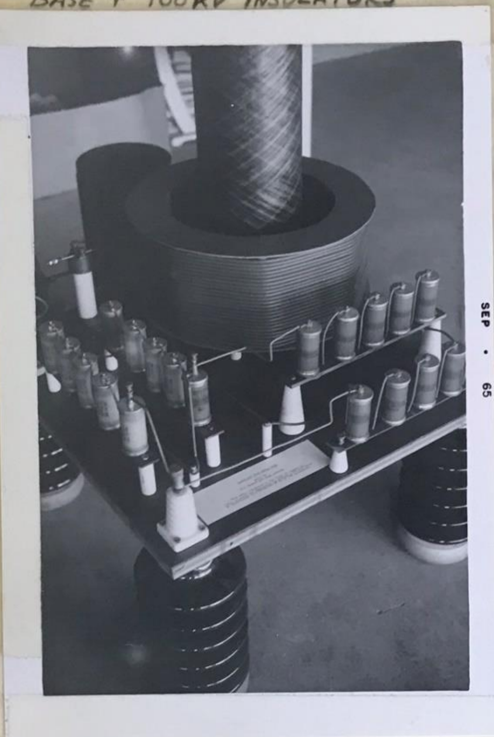
100 KV 60 MA.



1 TWO-SECOND EXPOSURE

(PG. 3)

PRIMARY COIL (25 T), INSULATION TUBE, CAPACITOR BANK (.01 MFD 80KV), BASE + 100KV INSULATORS



DOUBLE EXPOSURE. FIRST GREG (1/50 SEC. @ f 6.8, THEN 1/2 SEC. EXPOSURE OF ARC @ f 6.8.



DOUBLE EXPOSURE OF GREG, MYSELF, + COIL



← OUR HIGH-VOLTAGE LABRATORY... GREG'S GARAUGE. NOTE ALUMIMUM POLE AGAINST WALL (OUR "PORTABLE" LIGHTNING ROD)

(WE'RE TRANSPARANT BECAUSE OF UNDER EXPOSURE.)

July '65

Showing results obtained with 500 KV coil. Circuit of this coil on reverse side.

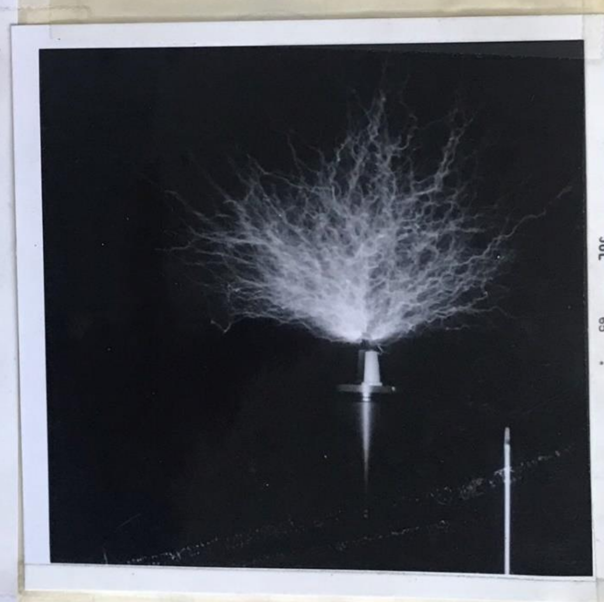
Discharge in photo #1 showing 20 inch arc, 1 second time exposure.

Corona brush in photo #2 38 inches in length, 1 sec. time exposure.

Secondary built by Greg Johnson



1



2

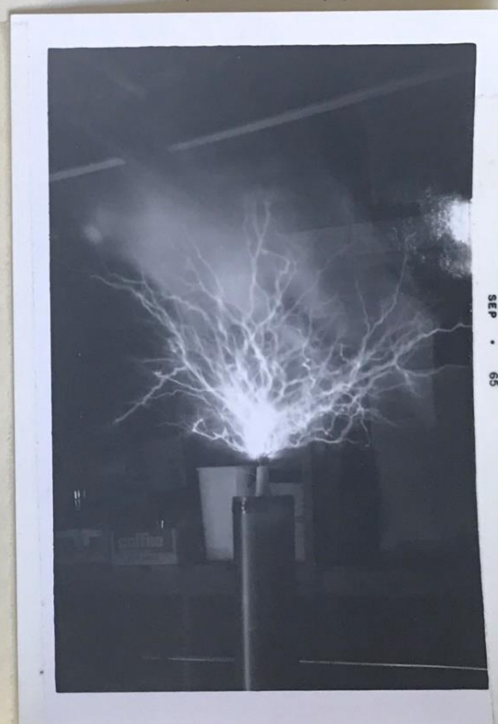
60 cm discharge tube glowing under influance of coil

...NTENNA IS COUPLED

(PG. 3)

A ½ SECOND EXPOSURE @ f6.8.
LONGEST DISCHARGE IN PHOTO
REACHED RAFTER LIGHT SOCKET.
THIS IS A 46" SPARK REPRESEN-
TATIVE OF ≈820 KV. BY ≡ T.E. 20KV
PER INCH OF DISCHARGE.
NOTE SMALL CORONA BURSTS FROM THE BALL.

ONE-SECOND EXPOSURE
OF THE SAME, IN FULL
ACTIVITY.



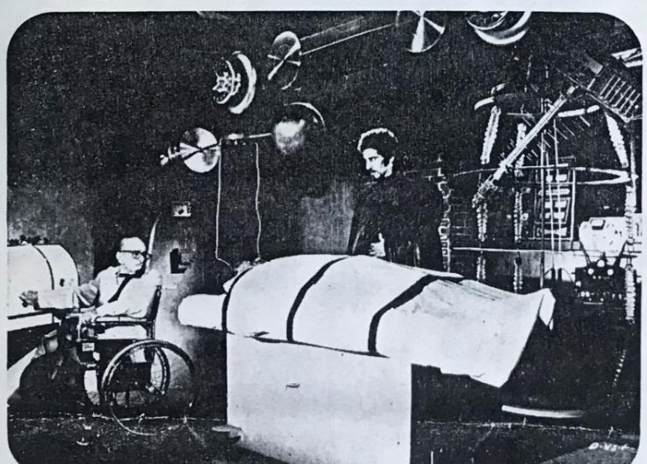
THE ELECTRICAL WIZARD OF THE MOTION PICTURES





■ Back in 1934, when sound films were still in their infancy, Brother Kenneth "Ken" Strickfaden, member of Local 40, Hollywood, Calif., was adding to motion pictures special visual effects that attracted worldwide attention. Already known as the "Electrical Wizard of the Motion Pictures," Ken, through his special effects, kept audiences sitting on the edge of their seats, sending chills up their spines, with his startling, blood-curdling effects in such films as *Dracula, Dracula vs Frankenstein,* etc. These effects—and others—he produced through the application of electricity and his knowledge of the principles of physics. Ken also produced effects that gave an image of a million volts, metal rings floating through air, black light, and many others. Having incorporated his most startling effects into an intriguing lecture, Ken was in great demand as an entertainer and educational lecturer. His obvious knowledge of the subject of physics, displayed in his effects which seemed to defy the law of gravity, made him a sought-after speaker before the Association of Physics Teachers. Born on May 23, 1896, Ken was initiated into Local 40 on October 31, 1927, and went on pension in June, 1961. And his spectacular effects in the blood-thirsty Dracula films, often shown after the spooky midnight hour, are still sending chills up viewers' spines.

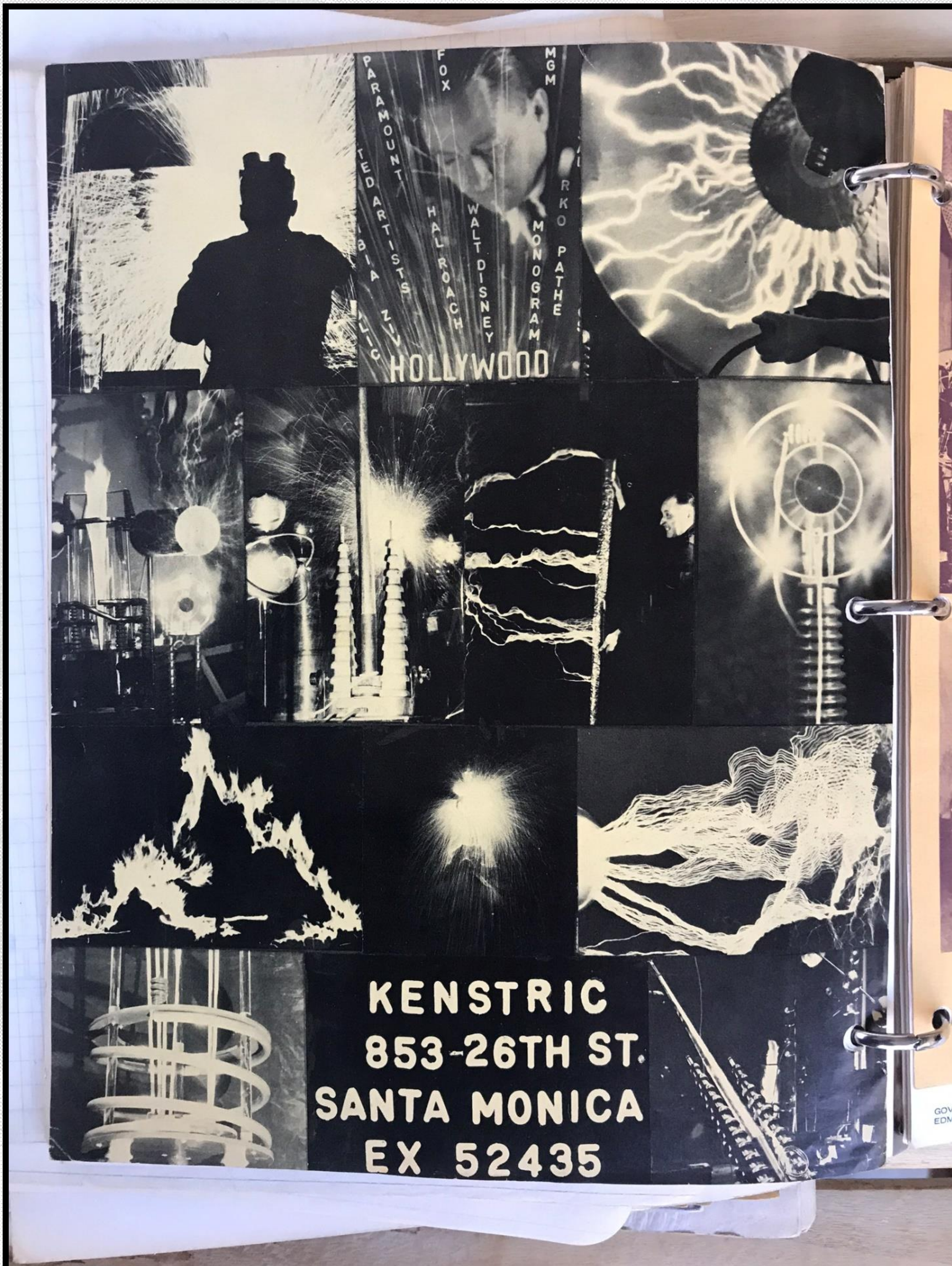




Brother Kenneth Strickfaden's electrical machines bringing the Frankenstein monster to life.

In the motion picture *Dracula vs. Frankenstein*, Dr. Frankenstein (J. Carrol Naish) and Count Dracula (Zandor Vorkov) prepare to revive the Frankenstein monster with the aid of the special effects lab Brother Strickfaden created.


INTERNATIONAL
EXPOSITIONS
PALACE OF ELECTRICITY
ELECTRICAL AGE
CALIFORNIA PACIFIC
GOLDEN GATE
EASTERN STATES


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FOX
MGM
TED ARTISTS
HAL ROACH
WALT DISNEY
MONOGRAM
RKO PATHE
ZIV
HOLLYWOOD
KENSTRIC
853-26TH ST.
SANTA MONICA
EX 52435

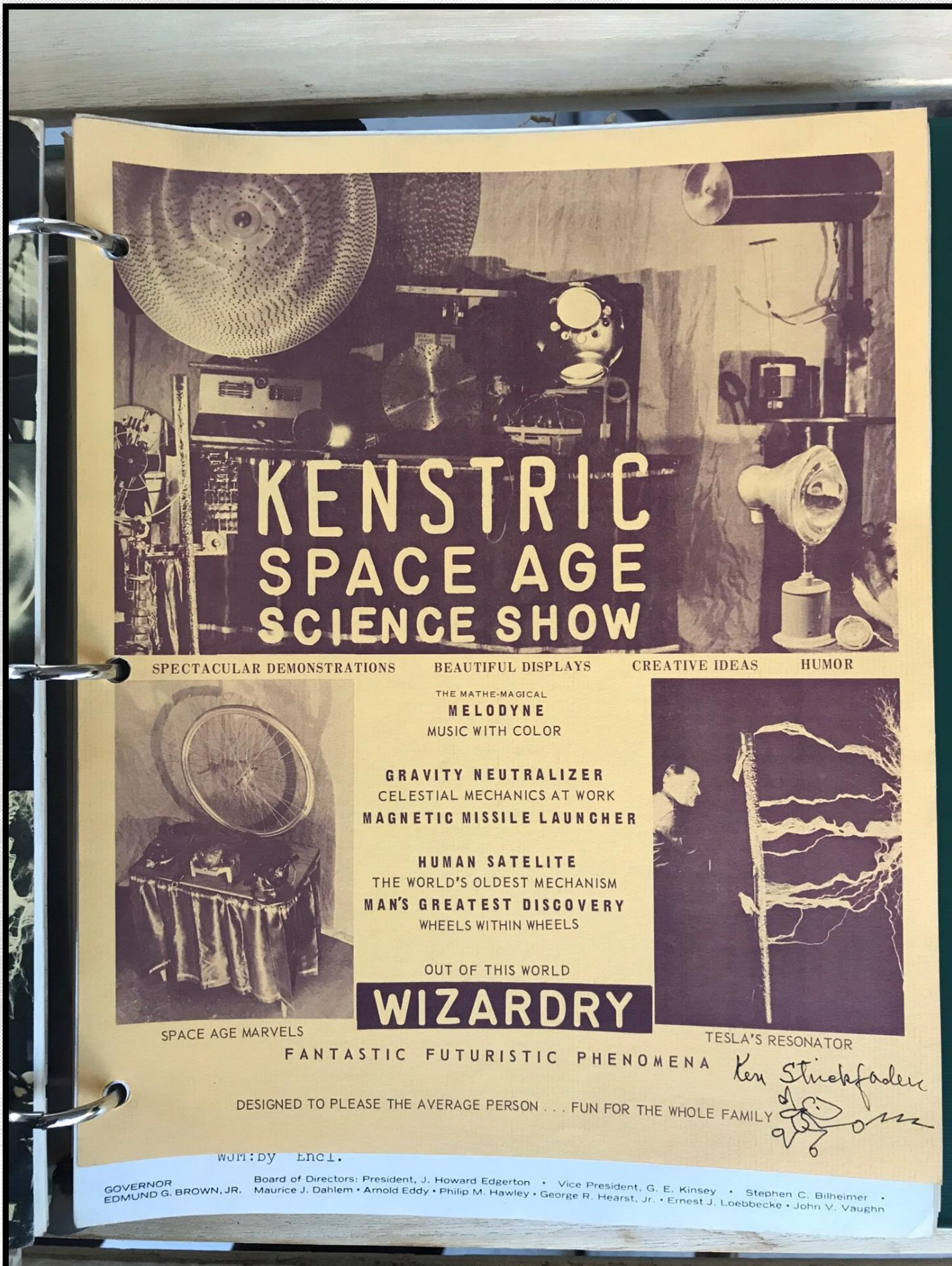
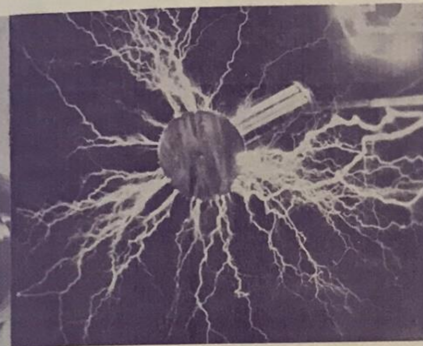

KENSTRIC
SPACE AGE
SCIENCE SHOW
SPECTACULAR DEMONSTRATIONS
BEAUTIFUL DISPLAYS
CREATIVE IDEAS
HUMOR
THE MATHE-MAGICAL
MELODYNE
MUSIC WITH COLOR
GRAVITY NEUTRALIZER
CELESTIAL MECHANICS AT WORK
MAGNETIC MISSILE LAUNCHER
HUMAN SATELITE
THE WORLD'S OLDEST MECHANISM
MAN'S GREATEST DISCOVERY
WHEELS WITHIN WHEELS
OUT OF THIS WORLD
WIZARDRY
SPACE AGE MARVELS
TESLA'S RESONATOR
FANTASTIC FUTURISTIC PHENOMENA
Ken Strickfaden
DESIGNED TO PLEASE THE AVERAGE PERSON . . . FUN FOR THE WHOLE FAMILY
WJM:by Encl.
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PHOTO CELL ORGAN



ELECTRICAL LACE



SYNTHETIC MUSIC

KENSTRIC
APPLIES SCIENCE TO
INTERPRETAINMENT

SPECIAL ELECTRICAL EFFECTS FOR MOVIES

KENSTRIC has provided the "FIREWORKS" for more than 60 "THRILLER" type films at the major studios. His "IMAGINEERING" apears in such MAD LAB creations as WAR OF THE WORLDS, WIZARD OF OZ, JUST IMAGINE, SHERLOCK HOLMES, FRANKENSTEIN, FLASH GORDON, UNDERSEAS KINGDOM, INVISIBLE RAY, LOST CITY.

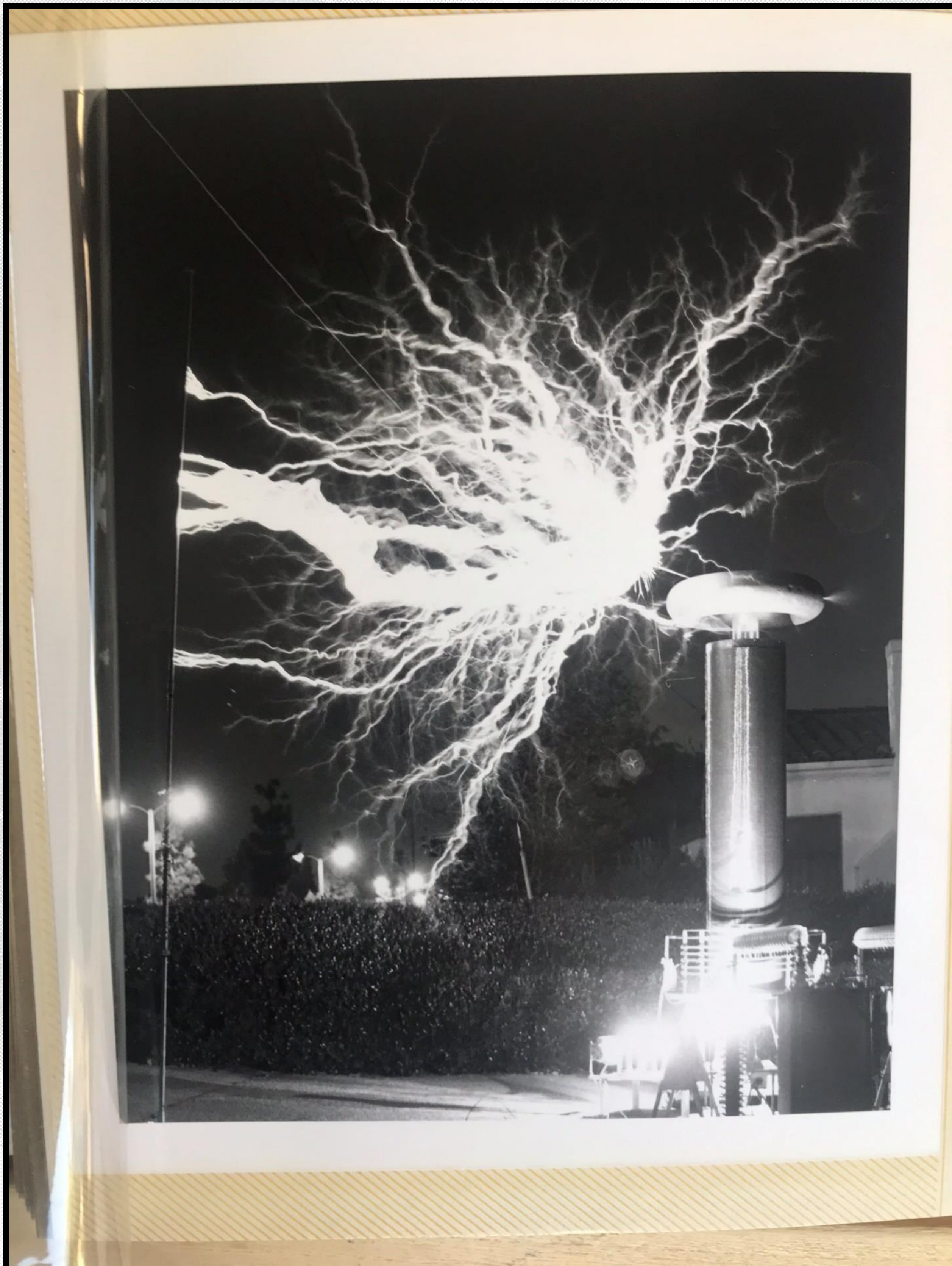
BOQUETS

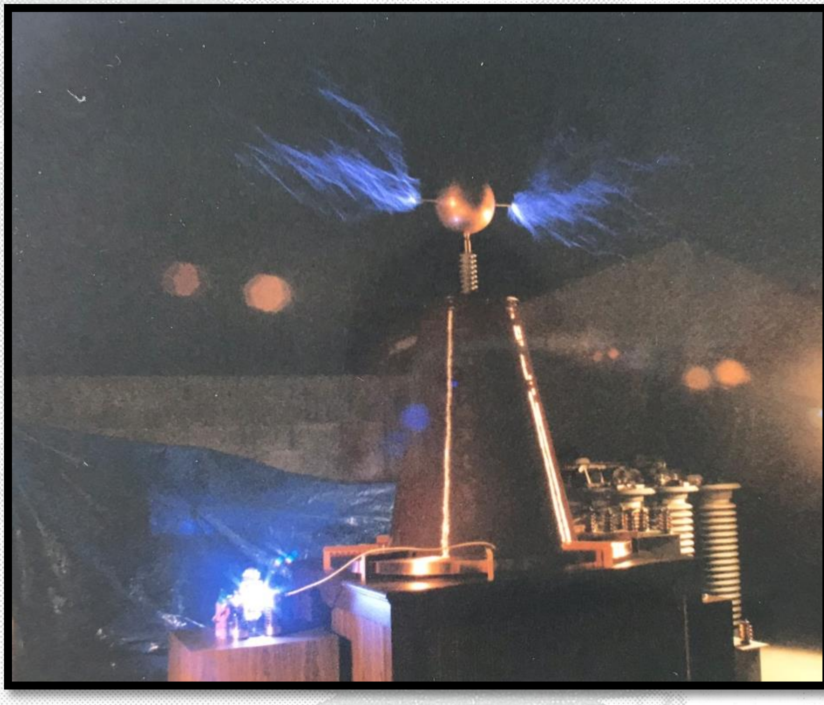
WILSHIRE MASONIC LODGE: *"..a spectacle of electronic and scientific display. Kenstric Science Show kept the gang awed and in stitches for an hour."* SAN DIEGO HI-HATTERS: *"..rare entertainment..inspiring music with color".* U.S. DEPT. of INTERIOR, Sherman Institute: *"..very much worthwhile..recommend".* SANTA MARIA J.C. *"..demonstrations enthusiastically received..please return."* LYNWOOD J.H.S. *"..the best program we have had this year."* DOWNEY ROTARY: *"..over a period of ten years, this was the most interesting."* LODI FESTIVAL: *"..one of the highlights of our entertainment program."* UTAH CENTENNIAL: *"..wonderful show..extensive equipment..greatly pleased."* ELECTRICAL AGE EXPO. L.A. *"splendid show..personal co-operation"* CALIF. PACIFIC EXPO. *"..Main attraction at PALACE of ELECTRICITY.., increased attendance 88%...don't hesitate to use me as a reference.."* UTAH STATE AGRICULTURAL COLLEGE: *"..hope students everywhere might have the opportunity to enjoy your demonstrations."* ALHAMBRA H.S.: *"..expressing our admiration for for your program."* LOS ANGELES VETERANS ADMINISTRATION: *"..performance intrigued interest."* SO. PASADENA H.S. *"exceptional from magnet to lightning."* LA SIERRA COLLEGE: *"..had our audience in the hollow of your hand."* U. of A. ARIZONA: *"..most favorable response...stimulating and instructive." "...every university community...should have opportunity to witness your exhibition."* PAN PACIFIC AUDITORIUM: *"..one of the most unusual..we had ever seen."* L.A. EXPOSITION: *"...interesting and entertaining...a highlight of Industrial demonstration period."* EDISON CO. *"...delighted...one of the highlights of our exposition...splendid show...personal cooperation."* BEVERLY HILLS *"spellbound...real productions of science."* MAY CO. L.A. *"...Frankly, we have never seen a more spectacular display...audience expressed a wish for your return."* BOY SCOUTS *"...excellent program...high calibre...educational."* GLENDALE ACADEMY *"...one of the most unusual...outstanding impression...looking forward to return visit."* TUSTIN H.S. *"...Hope to have you again...superior."* REDLANDS *"...most talked about show of the year."* HOLLYWOOD U.S.O. *"...amazing electrical demonstration...our compliments...masterful showman-ship."* NORWALK H.S. *"...enjoyed the program...held their attention from beginning to end...hope to have...again"* SOUTH PASADENA *"...highly pleased...exceptional...appreciated wit and humor."* ARLINGTON *"...how thoroughly we enjoyed your program."* DEMOREST *"enthusiastic...demonstrations are fitting for any school or church program."* VAN NUYS *"...ability to adapt your program...different age levels."* I.B.E.W. *"...magnificent and spectacular display of electricity..."* ORANGE H.S. *"...extremely well received...recommending this program...unusual and spectacular."* TULARE *"...well received by all ages. We were well pleased."* INSTITUTE *"...finest of comments concerning your demonstration and lecture...glad to recommend you."* RIVERSIDE *"...very much worthwhile and gladly recommend program."* WASCO *"...most interesting and instructive...entirely different..."* SANTA MARIA *"...most worthwhile...recommend to any school..."* VISALIA H.S. *"...received most enthusiastically...commend you upon your ability to hold the interest...clever personality...real showman... fascinating...this was one of the finest we have ever had."* TURLOCK H.S. *"...unanimous opinion of students, faculty and adults...program one of the most interesting and instructional..."* DOWNEY ROTARY *"...thoroughly appreciated by all...of ten years, this was the most interesting!"*

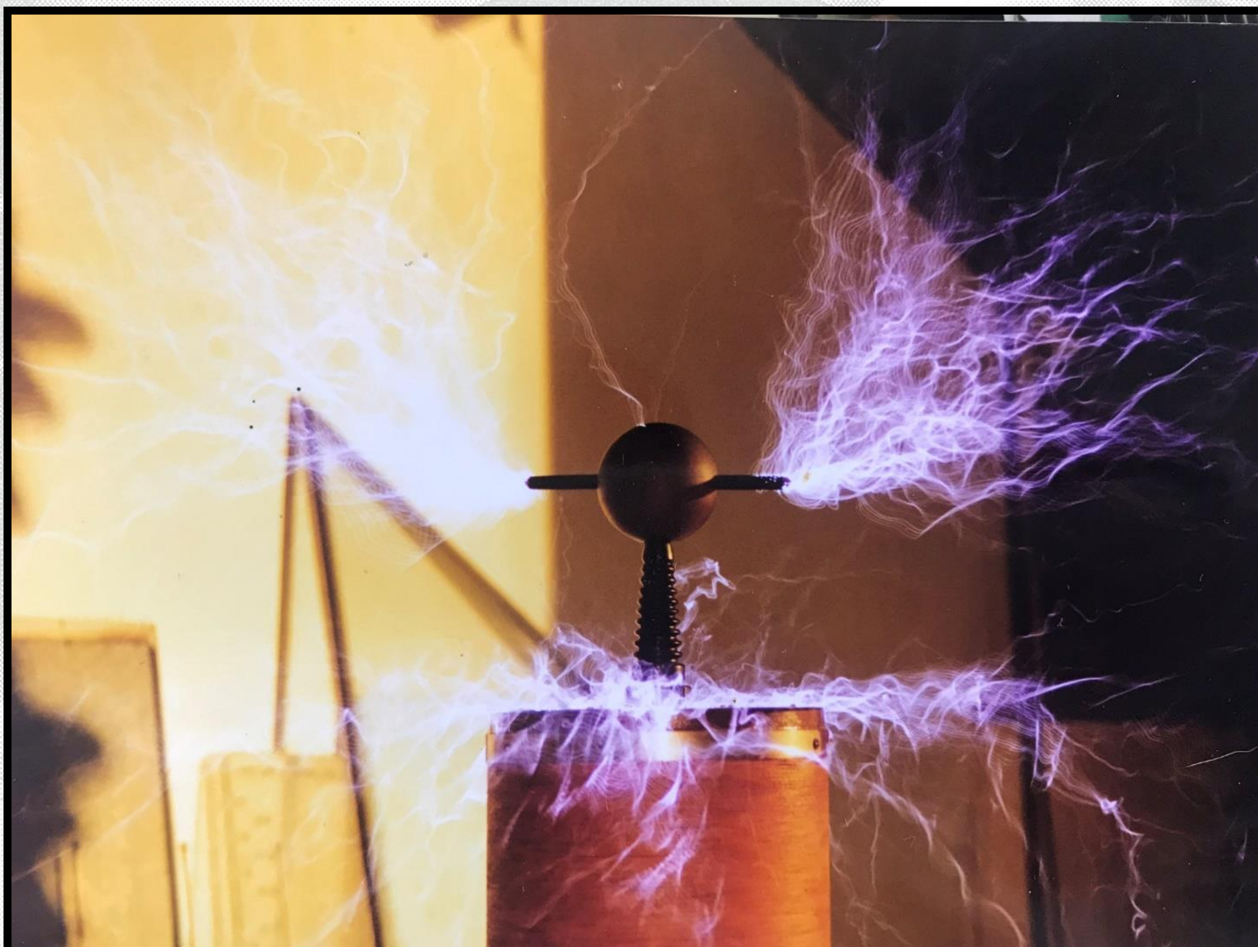
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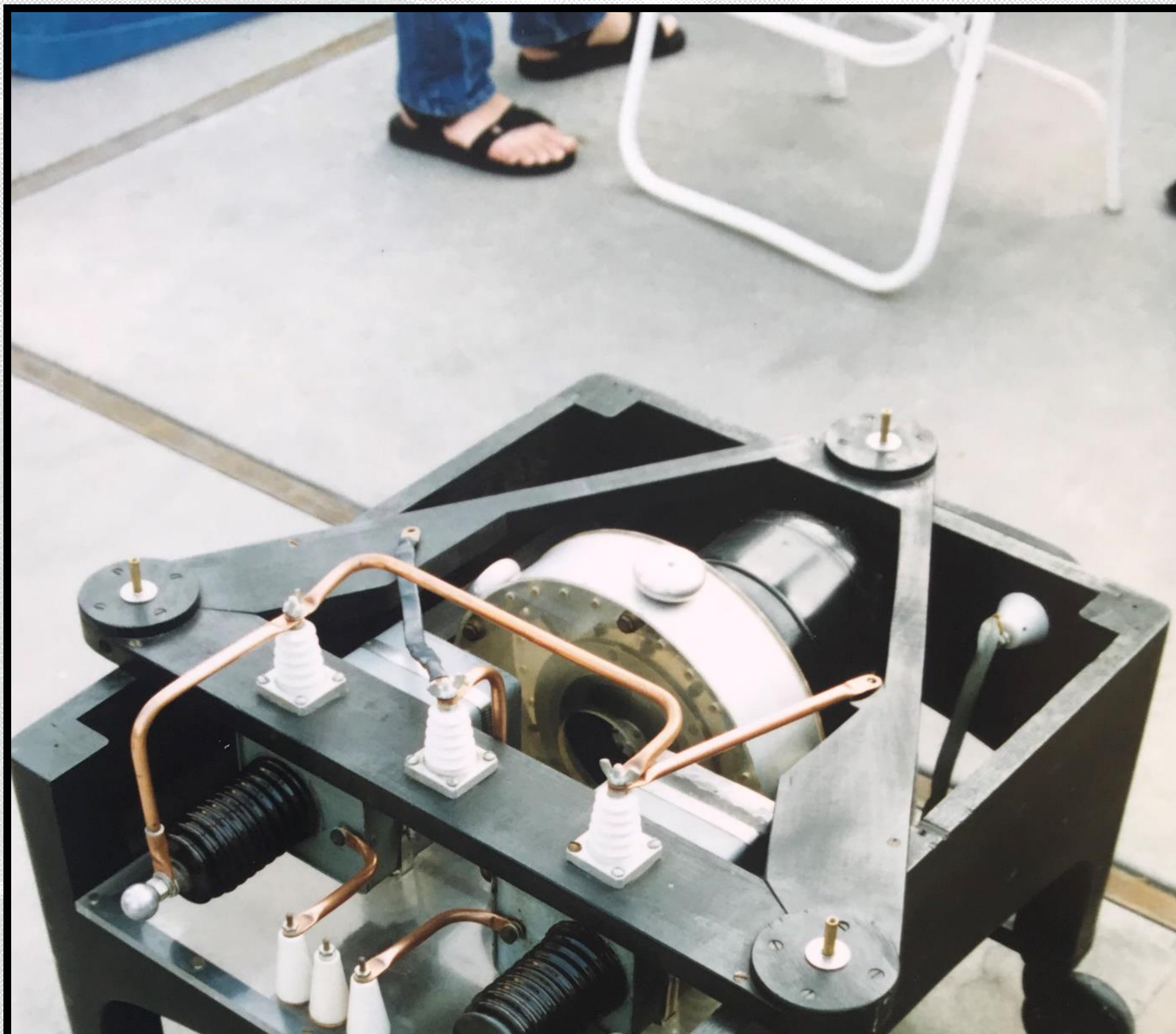
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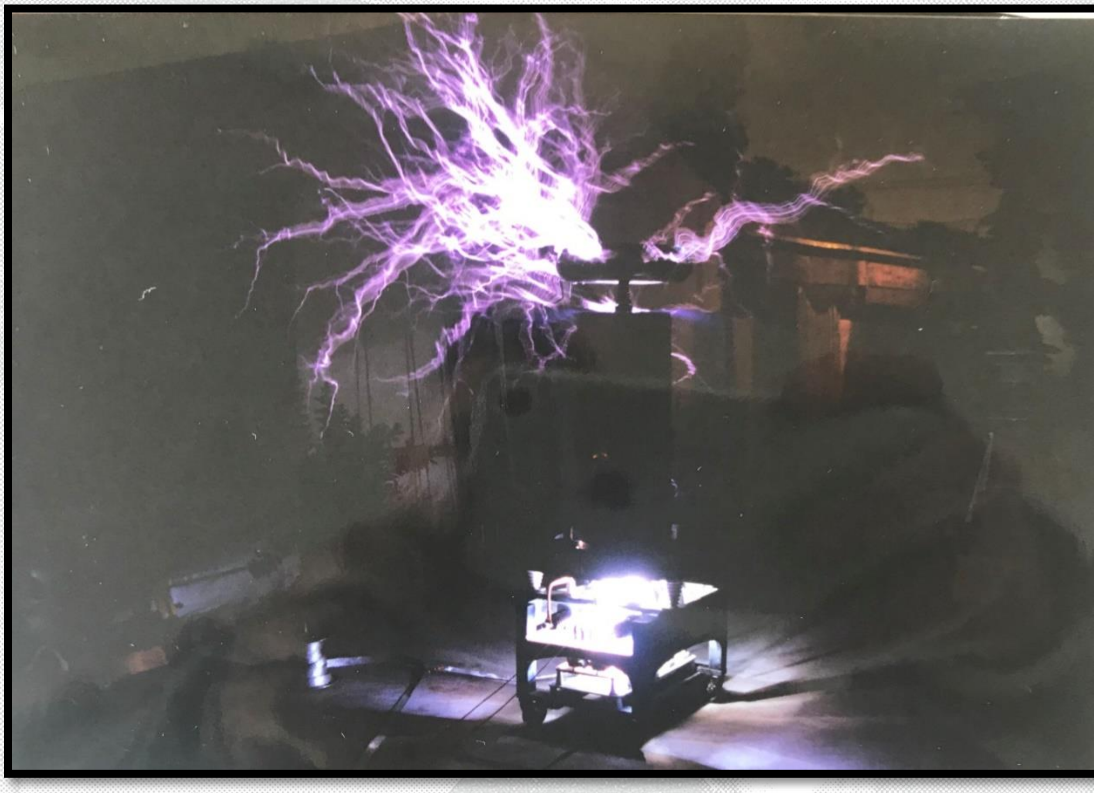














Richard Gibson (Dick) Aurandt, Kenneth Strickfaden, and Bill Wysock.
Dick Aurandt was Ken’s assistant, and built the impressive Tesla Coil on the previous page in 1939 with the terminal inspired by Earle Ovington.



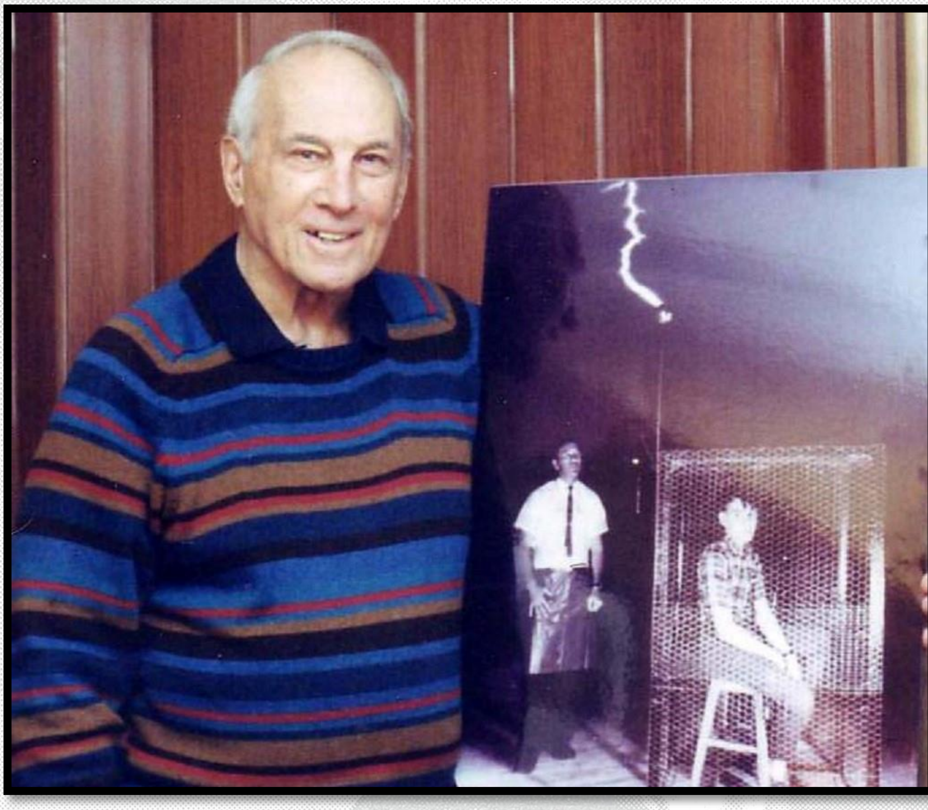
Dick Aurandt, charged with high voltage on top of a Tesla Coil. Sewing thimbles were placed on his fingertips to prevent RF burns.

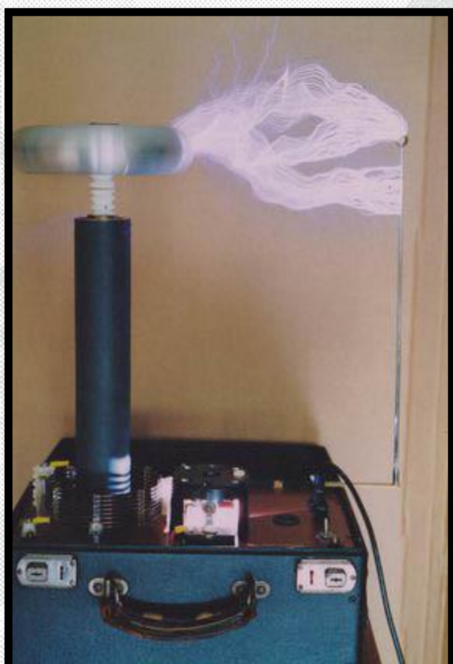


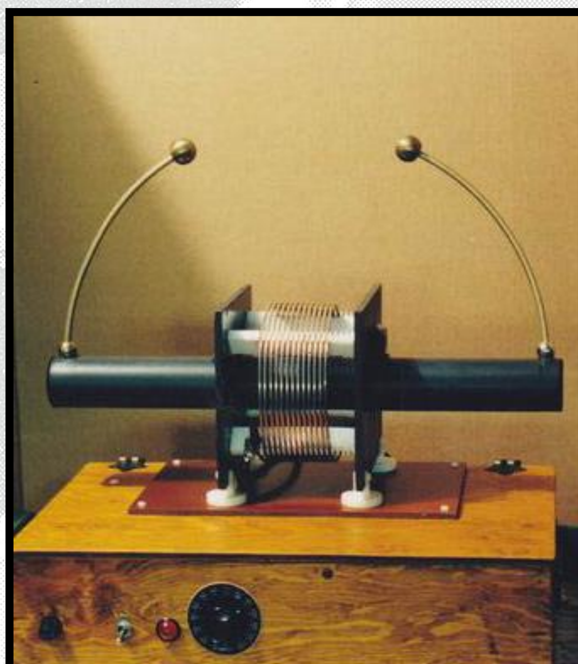
James (Jim) Hardesty (27 October 1945 – 09 June 2021) and Bill Wysock (18 June 1949 – 19 July 2013) in Jim's Lab. Jim was a historian, artist, philosopher, master craftsman, and one of the best public speakers I have ever encountered. I am fortunate to have considered both men my mentors. I wrote to them both as a teenager, and their responses were always nothing short of positive and full of encouragement.



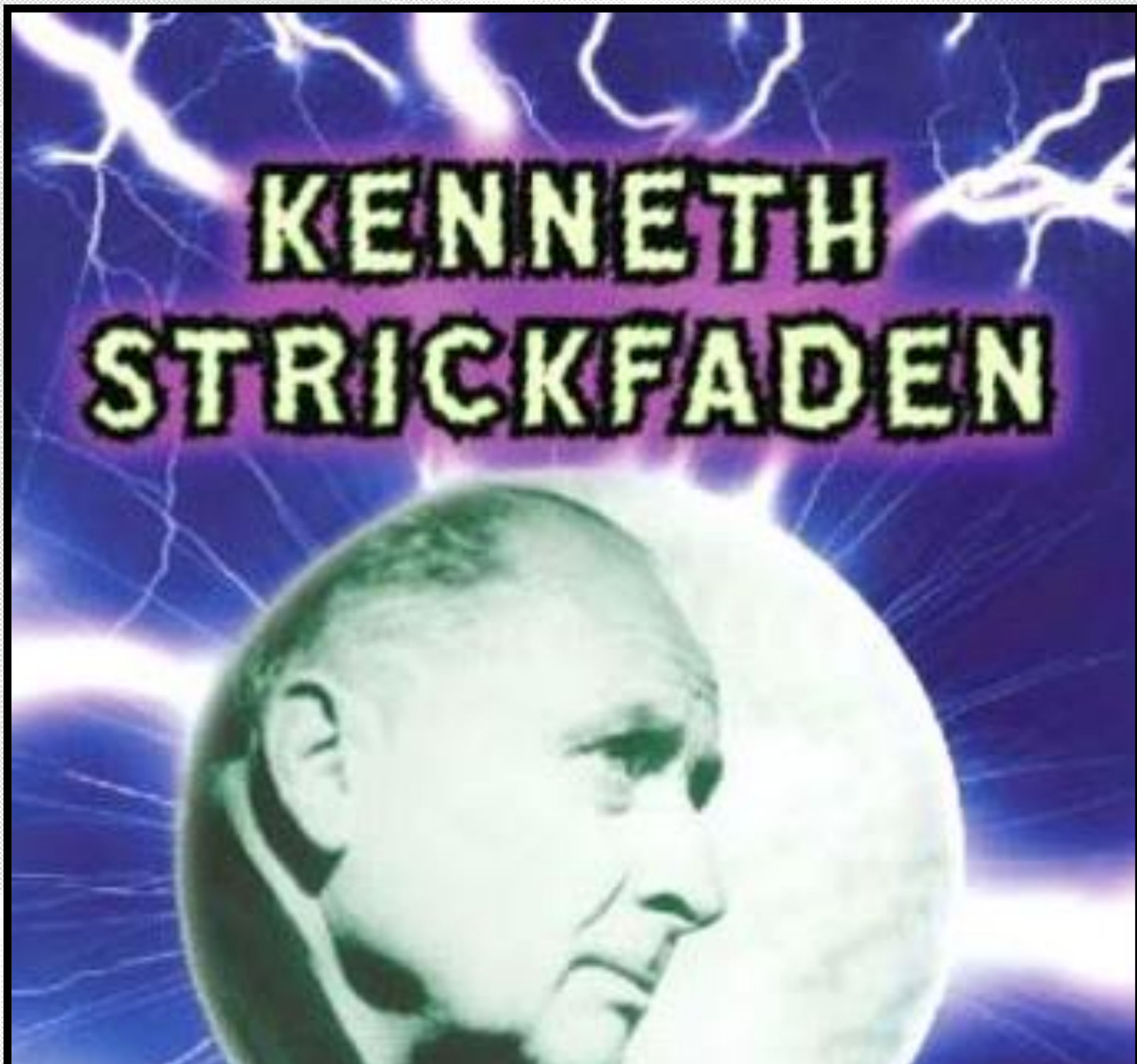
Jim Hardesty, Leland I Anderson, and Bill Wysock







Harry Goldman, Founder of Tesla Coil Builders Association News. An incredible friend and Tesla historian. He wrote the biography on Kenneth Strickfaden.


KENNETH
STRICKFADEN
DR. FRANKENSTEIN'S
ELECTRICIAN
HARRY GOLDMAN



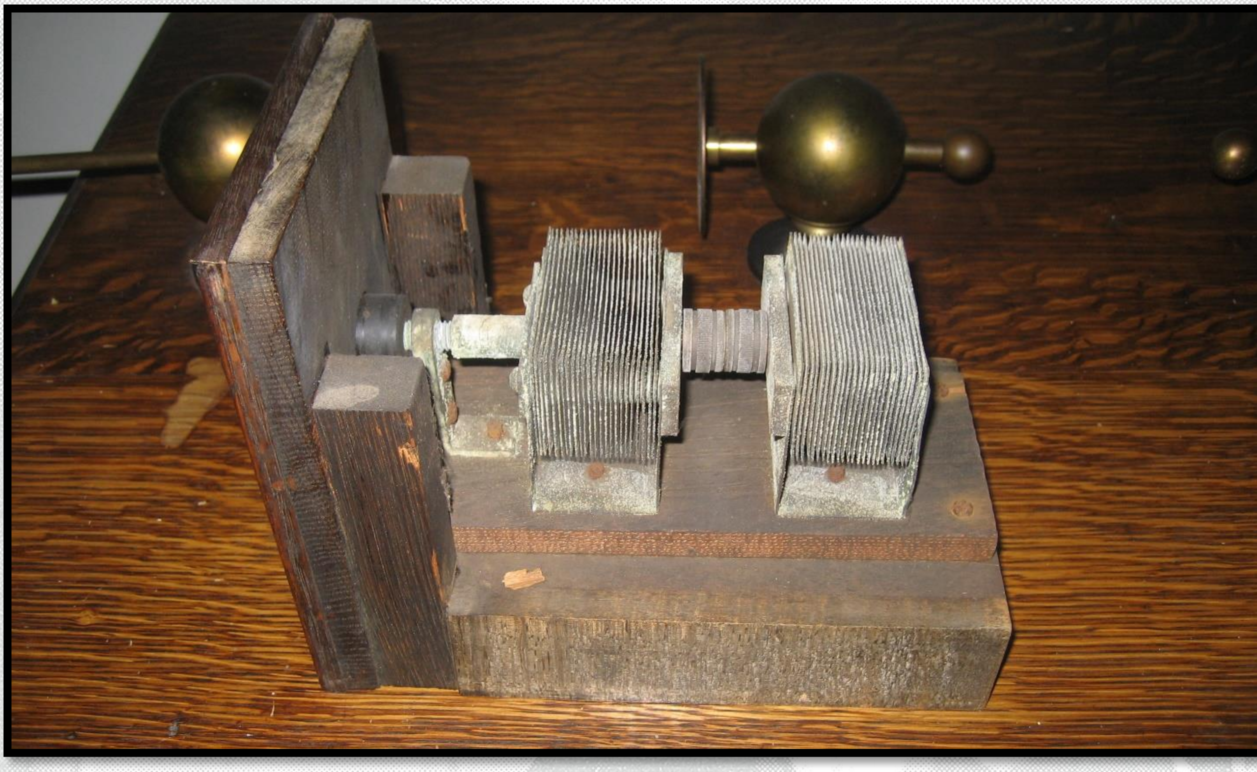


Dave Archer (15 January 1941 – 15 August 2023) was an extraordinary artist who developed a technique of reverse glass painting that used large Tesla Coils (designed by Bill Wysock) to mix the paints, creating electric space art. The paintings are most famously part of th Star Trek TV series, and are highly sought after by art collectors. Dave's son Forrester is now continuing the unique painting method in the tradition of his father.









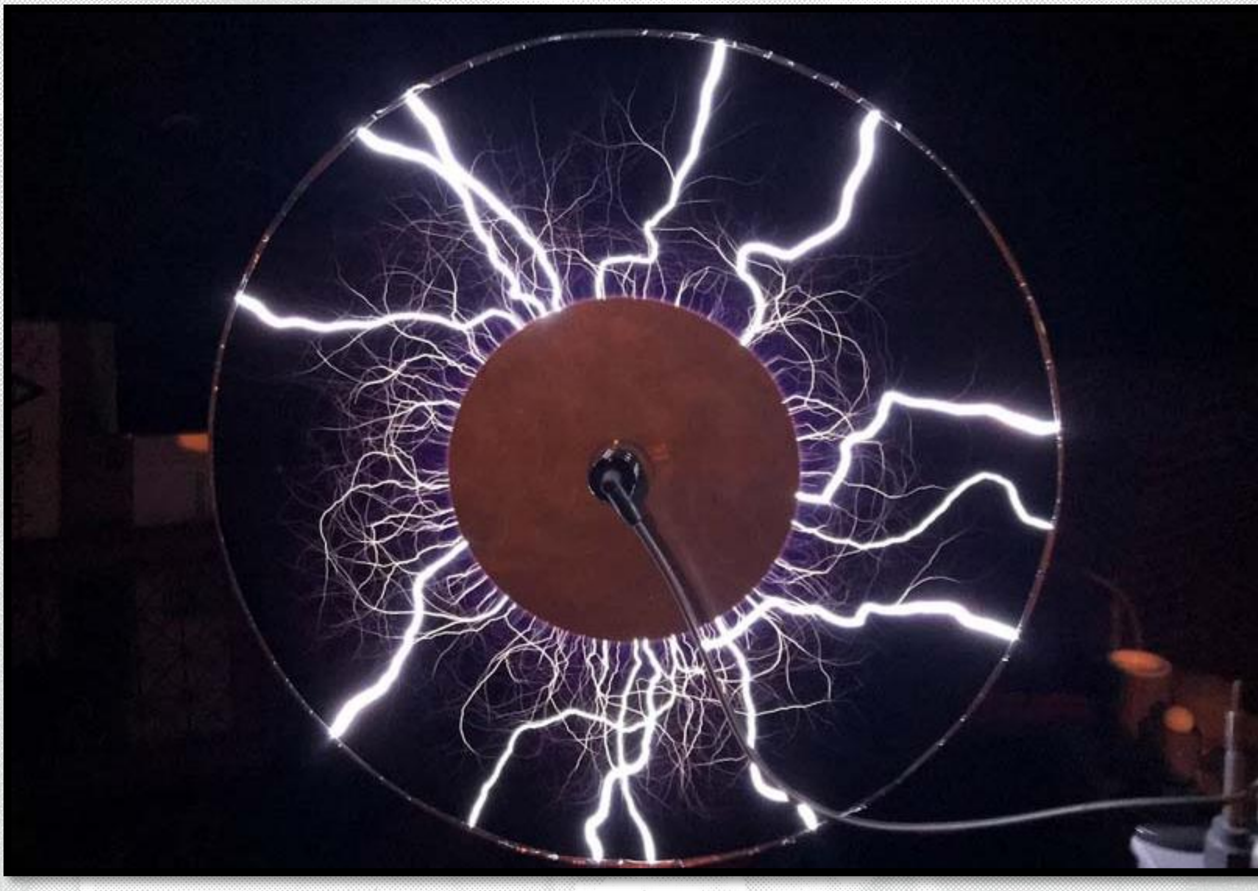


Electro-Radiation Company "Ajax Coil" found by Linda and documented by Bill & Francis Wysock.



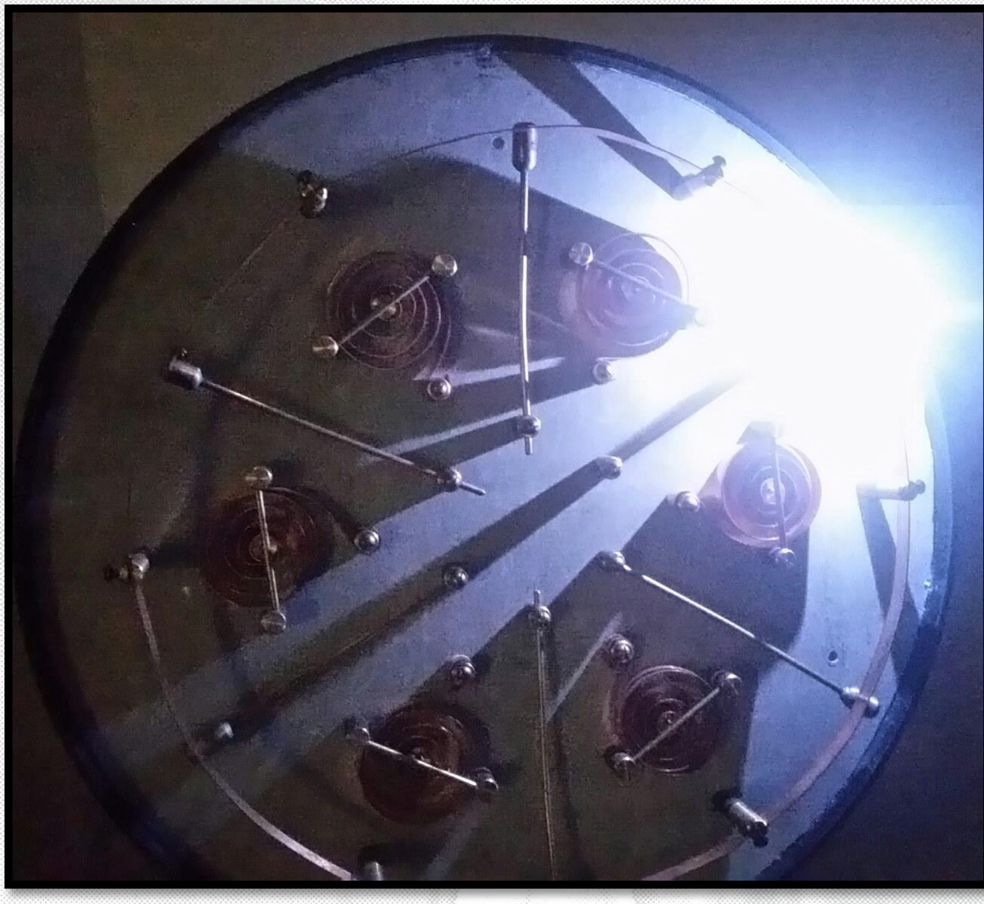


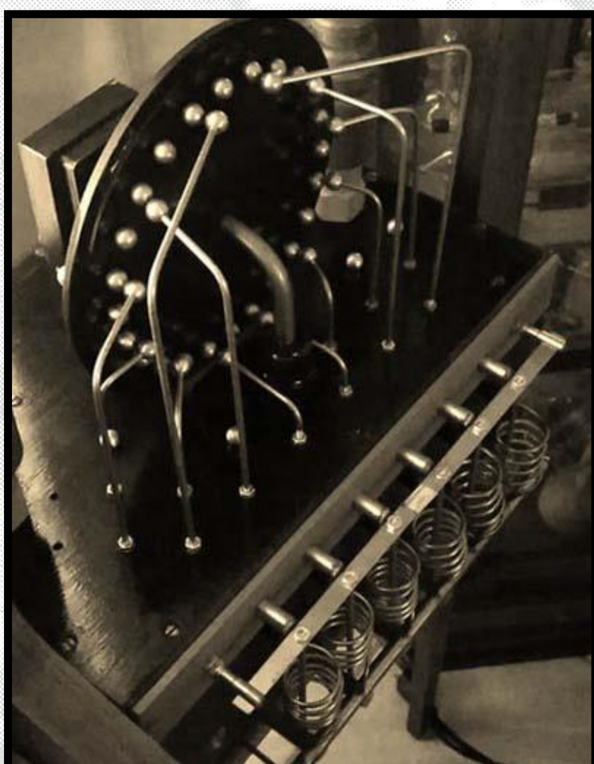
Top: Author with the Kinraide family and restored Kinraide Coil (top).
Thomas Kinraide, Rebecca Kinraide, John Grzywacz, Author, and Don Harris.
Below: Jeff Parisse of kVA Effects, Author, Carmen Miller, and John Jenkins of Spark Museum





Author with replica Kenneth Strickfaden Lightning Screen and Strong-Ovington Tesla Coil







Replica Strickfaden devices built by the author. “Digital Disputer”, “Cosmic Ray Diffuser”, “Nebularium”.



Thomas Burton Kinraide's Winter home Ravenscroft – Discovered by the author in 2004. Endless thanks to Steve Williams for letting me explore his beautiful mansion that Kinraide built…and for letting me keep the treasures of a lifetime I found below…





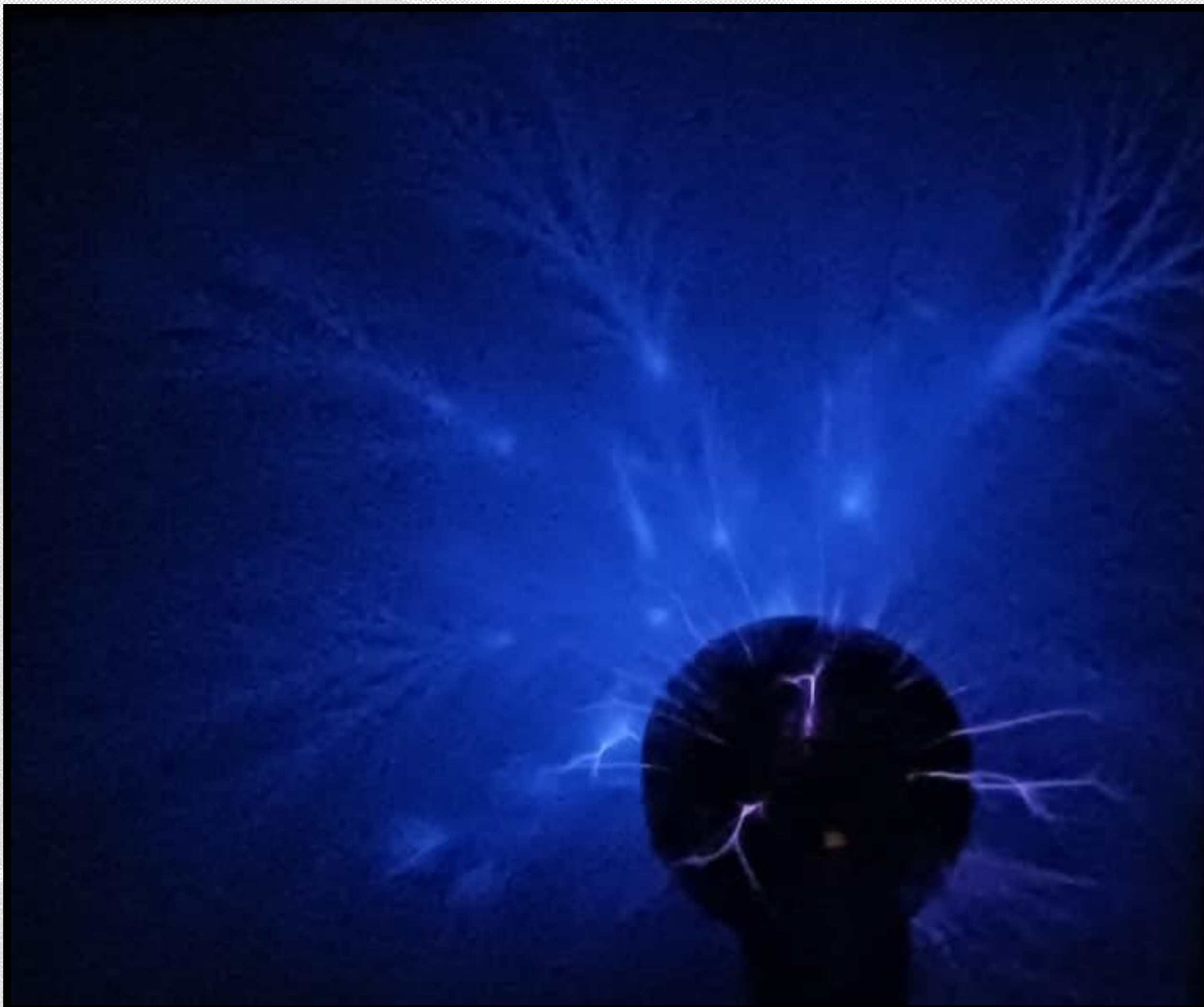


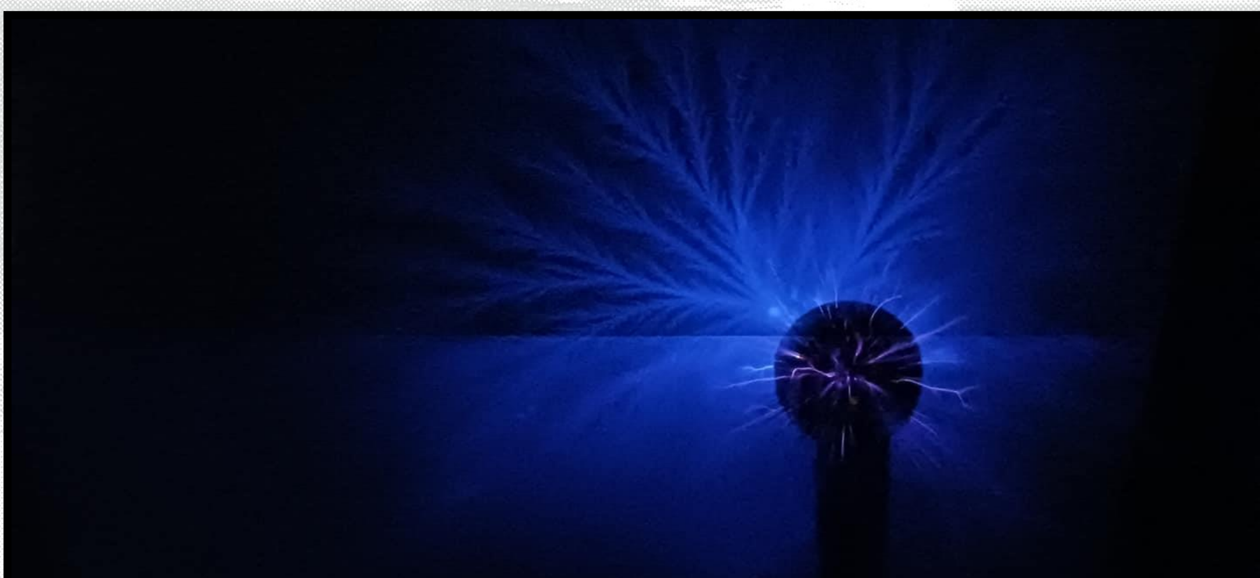
Hidden rooms containing the laboratories of Thomas Burton Kinraide as witnessed by
Dr. Frederick Finch Strong in 1896 and written about in his book High Frequency Currents.
The author found Kinraide's original apparatus in these 4 rooms along with hundreds of glass plate negatives of electrical discharges such as those in the Century Magazine "Curious Electrical Forms" article by Anabel Parker.





"Kathy Loves Physics", Author, Jeff Parisse visiting the Spark Museum in Bellingham, WA





On 05 September 2023 the author was granted a patent that includes replicating upper atmospheric lightning.

(12) **United States Patent**
Behary

(10) **Patent No.: US 11,749,970 B2**
(45) **Date of Patent: Sep. 5, 2023**

(54) **BROAD SPECTRUM ULTRAVIOLET SOURCES**

(71) Applicant: **RGF ENVIRONMENTAL GROUP, INC.**, Riviera Beach, FL (US)

(72) Inventor: **Jeffrey David Behary**, West Palm Beach, FL (US)

(73) Assignee: **RGF ENVIRONMENTAL GROUP, INC.**, Riviera Beach, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/461,432**

(22) Filed: **Aug. 30, 2021**

(65) **Prior Publication Data**

US 2022/0069549 A1 Mar. 3, 2022

Related U.S. Application Data

(60) Provisional application No. 63/073,106, filed on Sep. 1, 2020.

(51) **Int. Cl.**
H01T 1/22 (2006.01)
H01T 19/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01T 1/22*** (2013.01); ***H01T 19/00*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,447,766 A * 5/1984 Bedu H01S 3/092 315/173

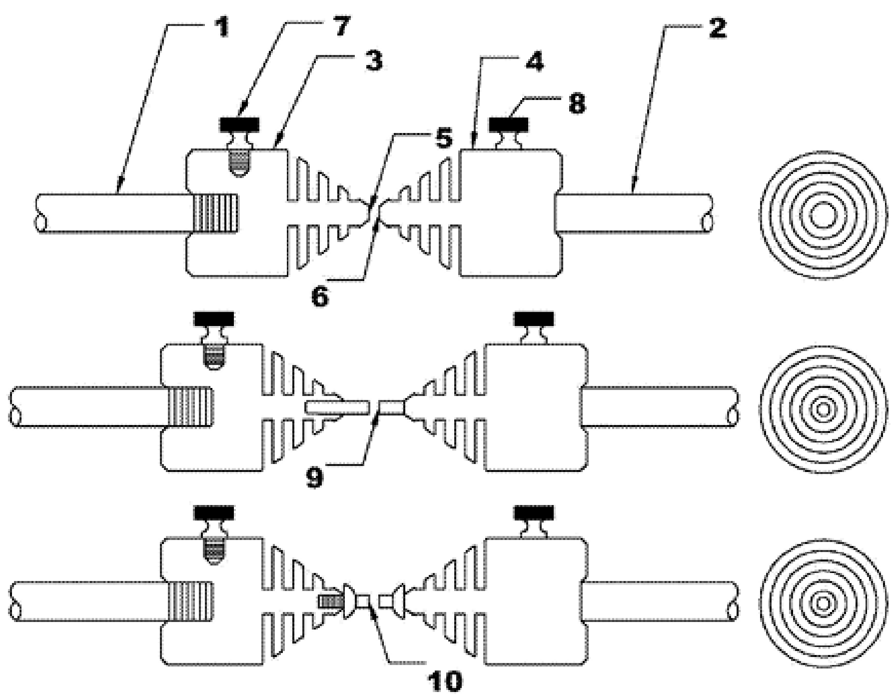
* cited by examiner

Primary Examiner — Ashok Patel
(74) *Attorney, Agent, or Firm* — ROTHWELL, FIGG, ERNST & MANBECK, P.C.

(57) **ABSTRACT**

In one embodiment, a device for generating broad spectrum ultraviolet radiation is provided. The device includes an adjustable spark gap of metallic solids, the spark gap including: a first electrode coupled to a first heatsink, and a second electrode coupled to a second heatsink, the second electrode spaced apart and opposite from the first electrode. The device includes a variable capacitor configured to discharge a voltage through the spark gap to generate broad spectrum ultraviolet radiation. The device includes a voltage source. The device includes a controller configured to control the variable capacitor. The first electrode is formed from a first metallic solid and the second electrode is formed from a second metallic solid, and the ultraviolet radiation generated is in the 140 nm to 400 nm range.

15 Claims, 163 Drawing Sheets



The 172-page patent is an extension of the work of Tesla, Kinraide, Strong, and Ovington,

XXI

FRANK HOWARD SWETT
1868–1929

FRANK SWETT was well-known to the early radiologists of New England. A merchant of the commodities and apparatus of the radiological laboratory, his was a familiar figure often seen here and there in the x-ray departments of the hospitals or in private offices. A genial and cheerful soul, his arrival with supplies was often most welcome at the scene of one of the little accidents or emergencies so well remembered by the pioneer.

Swett was of old Yankee stock. Born in Amesbury, Massachusetts in 1868, he was a son of John Howard and Annie (Williams) Swett. He was educated in the local graded schools and finally at Phillips Exeter Academy. His early life was largely devoted to various mercantile pursuits. Before the year of Röntgen's discovery he was engaged in the distribution of electric motors as agent of the General Electric Company, but sharing the general initial interest in that event and visualizing the possibilities in its medical development, in the spring of 1897 he formed an association with his brother-in-law, Mr. Clarence H. Lewis, for the distribution of x-ray apparatus to hospitals and to physicians. Their establishment in Boston constituted one of the first American ventures for this purpose. As a distributor of Crookes tubes and fluorescent screens especially, it became Mr. Swett's duty to demonstrate and test this apparatus for the information of prospective purchasers, and at first much of this work was done by means of a small influence-(static-) machine.

Swett's first dermatitis appeared on the back of the left hand. This slowly healed with the deposit of pigmentation,

to be followed, for some years subsequent to 1897, by similar attacks which in turn subsided, but later leaving keratosis-formation. It was not until the year 1905 that an ulcerative process formed on the back of the left hand, which failed completely to heal although showing a tendency to do so.

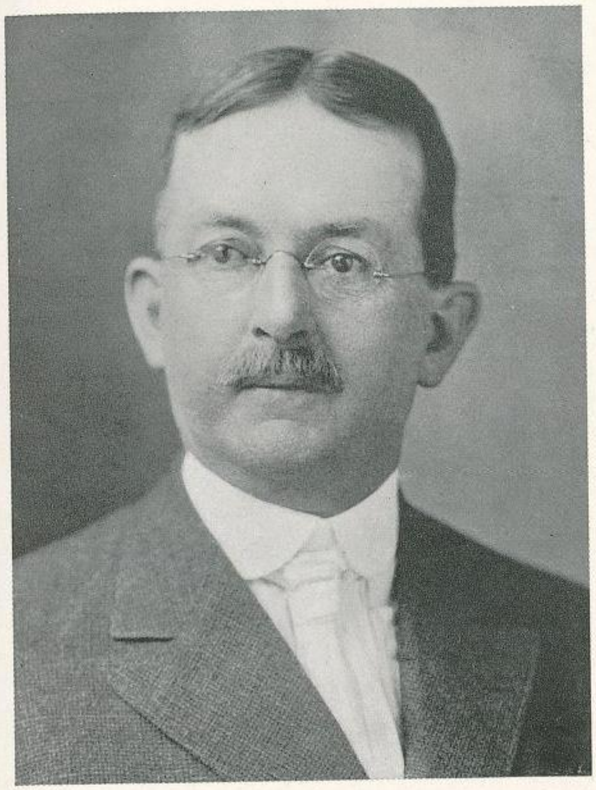


FIG. 49—Frank H. Swett

Many keratoses formed also on the left hand and the front of the chest, as well as a small persistent wart on the tip of the nose. These lesions were all successfully removed and wherever necessary were as successfully skin-grafted.

With this excellent reparative result Mr. Swett returned to the activity of his mercantile life. Being a merchant well-

liked and highly respected, his field of usefulness widened and he was the means of supplying much of the earliest x-ray apparatus to hospitals, physical laboratories and practitioners in urban New England. When his association with his brother-in-law was terminated, he joined forces with a group of Boston tube-makers and all were later combined as a branch of a large mercantile corporation engaged in the production of all forms of roentgen apparatus.

Swett's affability of manner and his generosity of his time and energies militated seriously against his physical well-being. During the six or seven years following 1908 he continued to work diligently, demonstrating—although now not so frequently by fluoroscope—and exhibiting apparatus that was rapidly developing in practicality and efficiency. A natural enthusiast, he gave little thought to his own condition, which seems not to have manifested itself acutely again until 1913, when a process of ulceration appeared on a thickened area of keratosis on the left forefinger. This was removed surgically and closed with a skin-graft.

In the early summer of that year by an unfortunate accident—the scratch of a cat, apparently trivial at the moment—the edge of this graft was wounded and an ulceration promptly appeared. This was removed and found by microscopical examination to be carcinomatous. Although the finger was immediately amputated, with healing in two weeks, it did not forestall the upward extension of the disease by metastasis. Toward the end of the year of 1914 the glands in the axilla and in the anterior wall of the chest were found to be involved. As soon as possible these glands were removed, as well as suspicious areas involving other fingers of the left hand.

In common with all who were engaged in the production and demonstration of Crookes tubes—*vide* histories of Henry Green, Rome Wagner, Burton Baker and others—Frank Swett sustained much x-ray damage to the tissues of the face,

lips and chest. Such lesions were the results of mechanical necessity, furthered by enthusiasm in the work and its future and glorified by a spirit of complete forgetfulness of self. From the year 1915 up to the moment of his death, almost, he submitted with the utmost cheerfulness to the unremitting efforts of his surgeons to stay the course of the disease in these regions. The length of time his life was conserved speaks strongly for their loyal persistence and his own never failing fortitude. More radium was used in his case than in any other of chronic radiation dermatitis recorded among the pioneers similarly affected, partly perhaps by reason of his own predilection for this form of treatment rather than orthodox surgery, but as time elapsed it seemed impossible to thwart the tendency to metastatic extension. In spite of radical surgical procedures to this end, Frank Swett died, a paragon of cheerful courage and stoical fortitude, his self-sacrifice crowning a life of continued usefulness.

"A quiet and unassuming man, who bore his burdens and did his work faithfully, effectively, patiently and without complaint. . . . He suffered that the realm of knowledge might be widened and humanity blessed with a new agency with which to combat disease."

SANDWICH INDEPENDENT

January 11, 1928

SANDWICH - Leaves three tubes of Radium

In the estate of the late Thomas B. Kinraide of this town, who died recently in California, an unusual and interesting discovery was made

The San Francisco Chronicle furnishes the following information: Three tubes found among the effects of the late Thomas B. Kinraide were labeled as containing altogether 1550 milligrams of radium.

The public administrator, Amos O. Williams, sent the tubes to the United States Bureay of Standards at Washington for analysis.

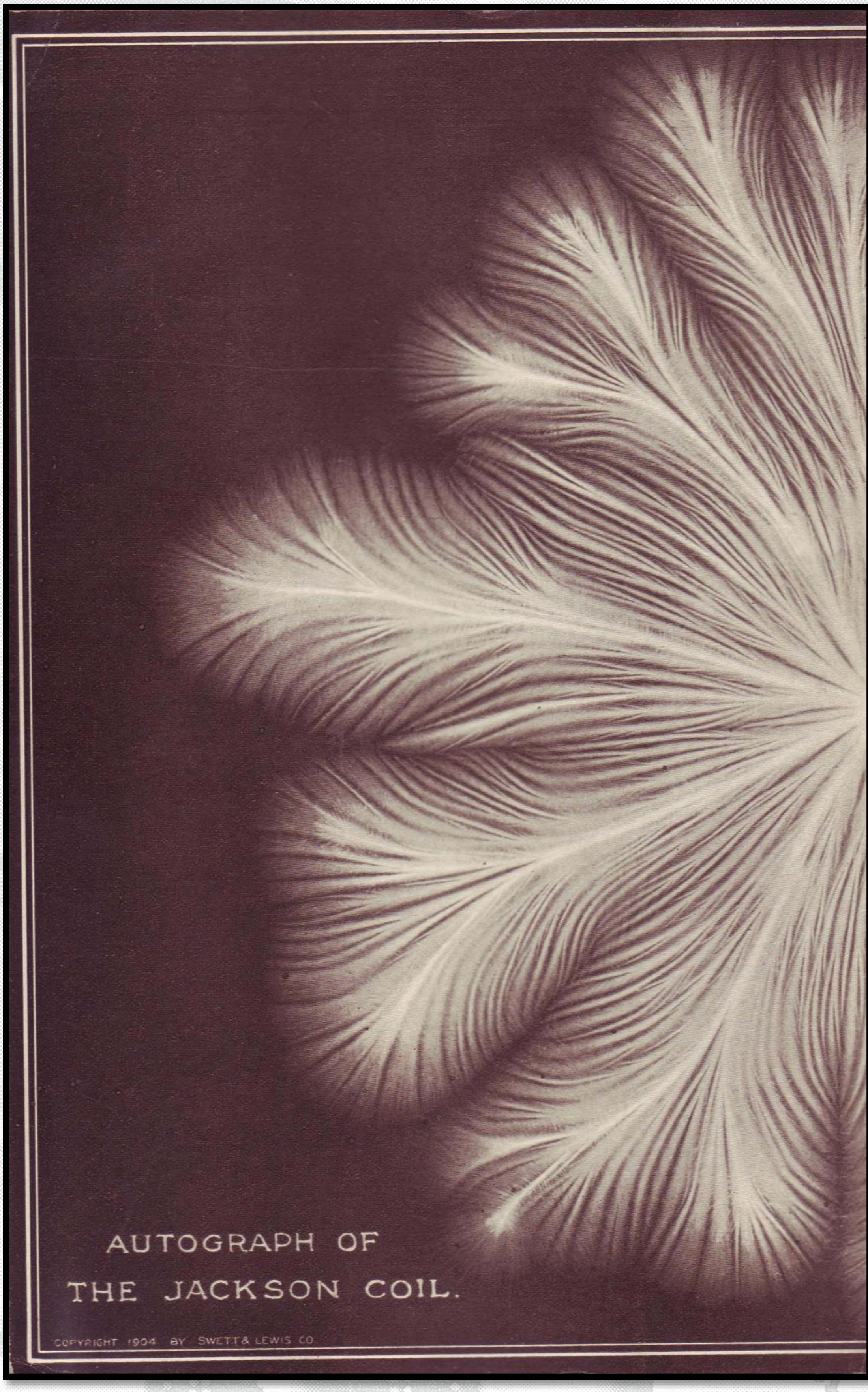
The tubes are supposed to contain $80,000 worth of radium.

Several from Sandwich attended the funeral services for Thomas Burton Kinraide, which were held from his late home in Jamaica Plain. Mr. Kinraide's death came as a great shock to his host of friends in Sandwich. When he resided here, his many acts of kindness and his generosity to those in trouble and sickness will long be remembered. He loved the old town and its people.

Hello Jeff,
I've checked the Newton Directories. He lived at 61 Waban Park in Newton. Howard Jackson died Oct. 16, 1929 in Andover, MA and was buried at Harmony Grove Cemetery in Salem, MA, his birthplace. In the city records Mr. Jackson was 62 years 7 months and 11 days old at the time of his death. Up until 1911, he is listed as an electrician. From the 1913 City Directory until his death, he was in the insurance business. (The notation in the city records says retired at the time of his death). He was the son of William H and Eliza H (Holman). Causes of death in the city records were chronic myocarditis, auricular fibrillation, arterio sclerosis with hypertension, and acute pulmonary edema. Here is the address for Harmony Grove Cemetery. Thanks for using our e-mail reference.
Alan
Reference Department Staff
Newton Free Library
330 Homer Street
Newton, MA 02464

Dedicated to the inventors and individuals mentioned in this book, and the pioneers of high frequency currents and early X-Ray apparatus.

While we don't know why Thomas Burton Kinraide (July 1, 1864 - June 29, 1927) had $80,000 worth of radium in his coat pocket when he died in San Jose California, one can only speculate it was try and save his friend's life. (Frank Howard Swett of the Swett & Lewis Company). All of the men mentioned in this book suffered negatively in some way from their casual exposure to X-Rays while trying to promote the field in pure fascination of the new discovery. $80,000 in 1927 was the equivalent of $1.4M today (23 September 2023). Kinraide did not need the money, he was quite wealthy from his inventions and highly eccentric and successful life.


AUTOGRAPH OF
THE JACKSON COIL.
COPYRIGHT 1904 BY SWETT & LEWIS CO

爱德华·汤普森 (EDWARD P. THOMPSON), M E，
专利律师。

教授。 WILLIAM A. ANTHONY，
电气和科学专家。

ALFRED C. COURSEN，
法律顾问。

美国和外国专利。

专利诉讼。

干扰案例。

商标、转让等。

关于专利性、侵权性
和实用性的意见等。

电气工程规范。

工作图和专利图。

建筑师电气规范。

电缆地址，

“科学，纽约。”

主要办公室：

纽约，康涅狄格州坦普尔考
特Nassau & Beekman Sts .,
靠近邮局。

---分公司：
华盛顿：大西洋大厦，靠近专利局。

地址：
纽约贝克曼街 5 号。
收件人：KWE

1896 年 3 月 6 日。

先生。尼古拉·特斯拉。

城市。

我亲爱的特斯拉先生。

看来你派了一位先生来这里为哈珀斯圆桌会议征集一篇关于伦琴射线的文章。经过一番犹豫，我同意为他写一些东西，现在我想要一些插图的东西。

如果你有你拍的照片，一些不常见的东西——不仅仅是手骨，而是比现在更新颖的东西，你愿意让我使用它们吗，当然要给予应有的认可文章中的他们。如果你有类似的东西，请寄给我三四个或大约 1/2 一打，我可以从中选择吗？

非常真正属于您的。

嗯。 A·安东尼.

爱德华·汤普森（EDWARD P. THOMPSON），M E，
专利律师。

教授。 WILLIAM A. ANTHONY，
电气和科学专家。

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靠近邮局。

分公司：
华盛顿：大西洋大厦，靠近专利局。

地址：
纽约贝克曼街 5 号。
收件人：KWE

1896 年 3 月 13 日。

先生。尼古拉·特斯拉。
纽约市。

我亲爱的特斯拉先生。

感谢您慷慨地帮助我删减伦琴射线文章。我几乎不知道如何描述我想要什么。

我想你可能有很多通过实验拍摄的照片，其中任何一张都会很有趣。

圆桌会议的人们想要一些与众不同的东西，这些东西在其他地方没有发表过。

几乎任何东西都能满足这个目的。

如果你能给我十到十五分钟的时间，也许会更好，那时我可以打电话到你的实验室，看看你有什么你愿意我应该使用的东西。

我知道您有多忙，我不需要占用您太多时间。

我同意在 21 日之前收到删减的副本，在 23 日或 24 日星期一或星期二之前收到文章的副本。

非常真正属于您的。

嗯。 A·安东尼

纽约，1896 年 3 月 16 日。
#46 & 48 东休斯顿街

Wm教授。 A·安东尼，
#5 比克曼街，
纽约市。
我亲爱的安东尼教授：-

您的来信已按时收到，但振荡器和伦琴波阻止我在此之前回复。

我会很高兴在您选择的任何时间在这里见到您。对我来说最方便的时间是下午3点到4点之间，但是你可以根据自己的方便来选择。

您非常诚挚的，

纽约，1896 年 3 月 20 日。
#46 & 48 东休斯顿街

Wm教授。 A • 安东尼，
#5 比克曼街，
纽约市。
亲爱的安东尼教授：-

很抱歉，由于昨天天气非常糟糕，无法在此之前向您提供照片。

我向您转发四张印刷品，一只兔子，一只松鼠，一箱从大约半英寸的密木和一些衣服中取出的绘图工具，以及一个显示真空管的盘子，一个铝圆盘和一个方形铜盘。相同的厚度。

希望这能起到作用，我仍然，
此致，

爱德华·汤普森 (EDWARD P. THOMPSON), ME ,
专利律师。

教授。 WILLIAM A. ANTHONY ,
电气和科学专家。

ALFRED C. COURSEN ,
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靠近邮局。

分公司：
华盛顿：大西洋大厦, 靠近专利局。

地址：
纽约贝克曼街 5 号。
收件人：KWE

1896 年 3 月 24 日。

先生。尼古拉·特斯拉。
城市。

我亲爱的特斯拉先生。

星期六早上我找到了这些照片, 并立即把它们带到了哈珀斯杂志。他们的时间很充裕。那是多么壮丽的图画啊。我该如何向您表达我对您的好意的感激之情？

我一直在思考玻璃管内部的反射。可以肯定的是, 理论上, 即使源是一个数学点, 最终的效果也应该是均匀分布的。

设S为源，A’ B’ 为管。 A A ’敏感板。 S 将具有一个两倍于管直径的环形式的图像。 S’ S’’ 将是该环的两个元素。射线 [NT -2-] [难以辨认] [NT -3-]

换句话说，问题是，在真空中（如在空气中），射线是否会从管的末端开始？另一个敏感板可以放置在 b 处。

真空管可能被铜包围，直到辅助管。

非常真正属于您的。
嗯。 A • 安东尼

纽约，1896 年 3 月 25 日。
#46 & 48 东休斯顿街

Wm教授。 A•安东尼，
#5 比克曼街，
纽约市。
我亲爱的安东尼教授：-

你方 3 月 24 日的来信已正式收到。我很高兴对这些照片感到满意。我应该说明距离为 20 到 24 英寸，曝光时间为 5 到 15 分钟。

关于管、玻璃或铜的反射，正如我前几天在进行实验时告诉你的那样，在我看来，该测试并不像我在《电气评论》（上一篇）上发表的实验那样具有决定性。我现在发现你是对的，管末端的场应该是均匀的。第一个实验没有证明这一点，但在一侧边缘附近显示了一个发光圆圈。我认为，管状空间内部的影响增加可能是由于管外部的空间受到的影响较小。直到后来，在我最终证明了反射之后，我才想到在许多实验中使用同一个板的计划。

由于我已经演示了反射，因此很容易放大对板上的影响，并且我对[原文如此]结果感到感兴趣。

我不认为 JJ Thomson 教授发表的实验是结论性的。他很可能使用的设备不足，可能无法检测到任何东西。但我认为，即使他有一个能够产生这种效果的装置，也仍然不是决定性的；但这会让我走得太远。

你关于将盘子放在单独的真空中的建议可能会带来一些有趣的启示。我会记住它，如果有时间我会尝试一下。

您忠诚的，

新型非磷光晶体，明显优于钨酸钙
春天公园实验室，
制造商
科学和电气仪器，
X 射线服装
精细化学品。各种尺寸的钨酸钙晶体。
荧光镜、荧光屏、照相屏、克鲁克斯管、
用于板或溴化纸的 X 射线照片板架。
春天公园大道 38 号
结核病金雷德，特里斯。和经理。
牙买加平原，2 月 24 日 - 1897 年

尼古拉·特斯拉先生；

尊敬的先生，

我们向您发送了一个由我们的非磷光晶体制成的小样品屏幕，它被认为是对广泛使用的钨酸钙的巨大改进。如果您愿意告诉我们您喜欢什么尺寸，我们将（免费）向您发送由相同材料制成的荧光镜，因为我们希望您彻底试用我们的荧光镜。

我们这样做并不以任何方式征求您给我们关于它们的推荐：除此之外，您自然会对您认为适合任何特殊用途的任何东西做出评价。如果您发现我们的屏幕比市场上大多数其他屏幕更好，您自然会参考它们以及我们不会询问或期望的更多内容。

相信您会让我们寄给您一台荧光镜，我们真的是您的，
Spring Park 实验室，TB Kinraide先生

纽约，1897 年 2 月 25 日。
#46 & 48 东休斯顿街

TB Kinraid先生，
斯普林公园大道 38 号
马萨诸塞州牙买加平原

我亲爱的先生：-

你2月24日的来信已收到。

我自然对每一项进步都感兴趣，并准备承认那些在我看来是应得的进步。但我的原则是不发表任何用于商业用途的公开声明，即使是我最好的朋友。但是，如果您认为您有任何比旧屏幕更好的屏幕，请给我发送一个，并让我像您的其他客户一样支付费用。只有这样的条件我才有可能接受。

我将非常感谢您对此事的关注。
您非常诚挚的，

新型非磷光晶体，明显优于钨酸钙
春天公园实验室，
制造商
科学和电气仪器，
X 射线服装
精细化学品。各种尺寸的钨酸钙晶体。
荧光镜、荧光屏、照相屏、克鲁克斯管、
用于板或溴化纸的 X 射线照片板架。
春天公园大道 38 号
结核病金雷德，特里斯。和经理。
牙买加平原，3 月 15 日 - 1897 年

尼古拉·特斯拉先生
休斯顿街 46 号

马萨诸塞州波士顿。

尊敬的先生：

今天，我们向您推荐一款非磷光荧光镜，我们认为经过试用，您会发现它比一般使用的钨酸钙晶体优越得多，因为没有磷光使图像模糊或变暗，并且物体的清晰度更加清晰和锋利。

当您说您从未发表任何用于商业用途的公开声明（即使是为您最好的朋友）时，我们感谢您的态度。我们并没有期望或要求您做任何类似的事情，并且担心如果我们的沟通对这种解释持开放态度，我们的表达能力会很差。

但是，我们会向您发送荧光镜，您可以提交该荧光镜进行测试并与任何其他荧光镜进行比较。我们应该很高兴向您提供礼物，以表达我们对您所做的原创工作的赞赏：但如果您坚持付费，只有在您发现它是您想要的东西之后才这样做。

非常真实的你，
斯普林帕克实验室
TB Kinraide先生
K

纽约，1897 年 3 月 21 日
#46 & 48 E. Houston Str.

春天公园实验室，
#38 公园大道，
马萨诸塞州牙买加平原

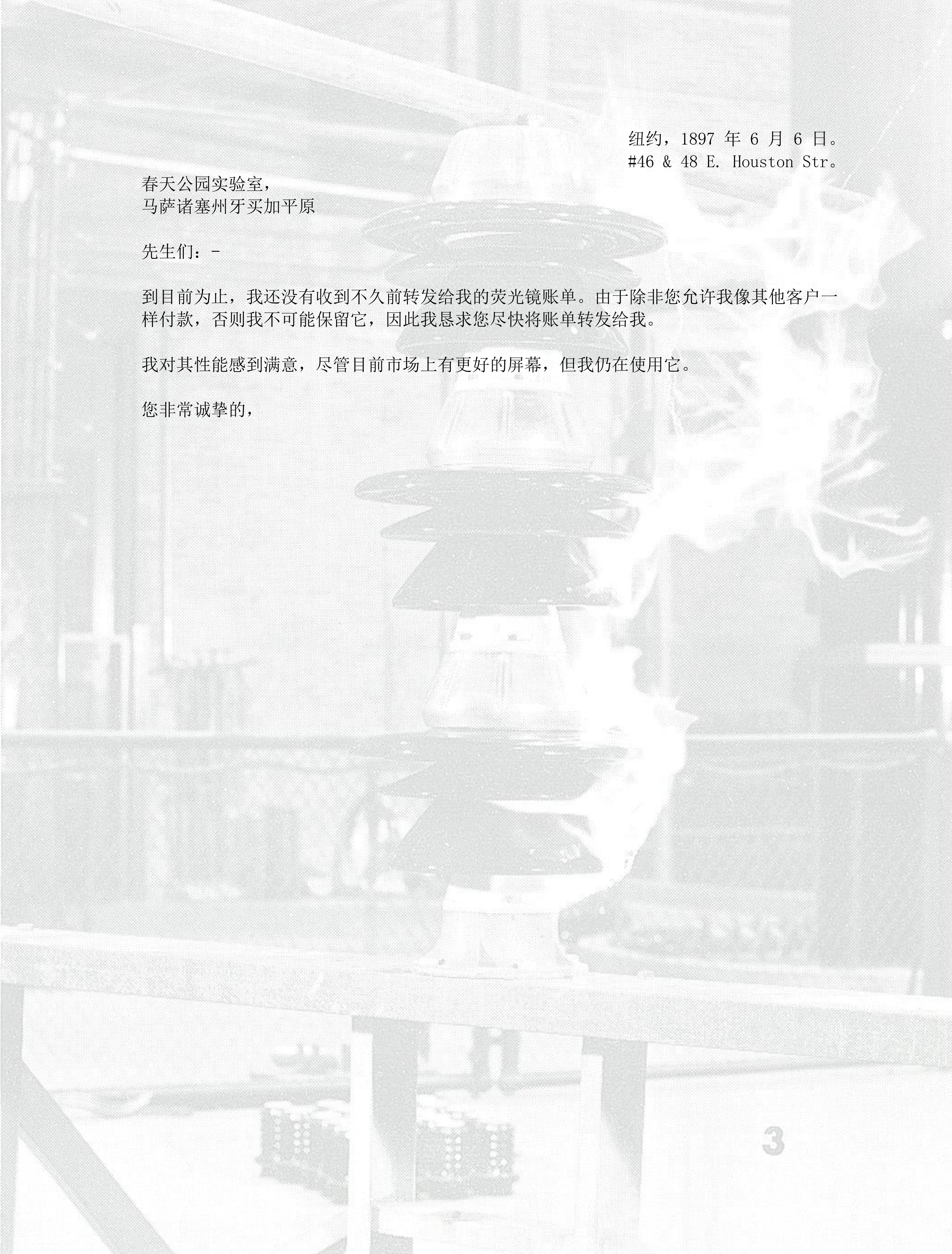
先生们：-

您3月15日的恩惠已收到。你的伦琴屏幕也到达了我的手中，我发现它很令人满意。我不想评论它与其他人相比的优点，只想说我会保留它。请在您方便的时候尽早将帐单邮寄给我。

在检查屏幕时，我注意到您已经利用了一些建议。我并不是以任何批评的态度这样说，相反，我很高兴你这样做了，并且欢迎你从中获得任何可能给你带来的好处。

如果您有任何新的磷光材料，我希望您能寄给我一些进行试用。

相信我是，
您非常诚挚的，



纽约，1897 年 6 月 6 日。
#46 & 48 E. Houston Str。

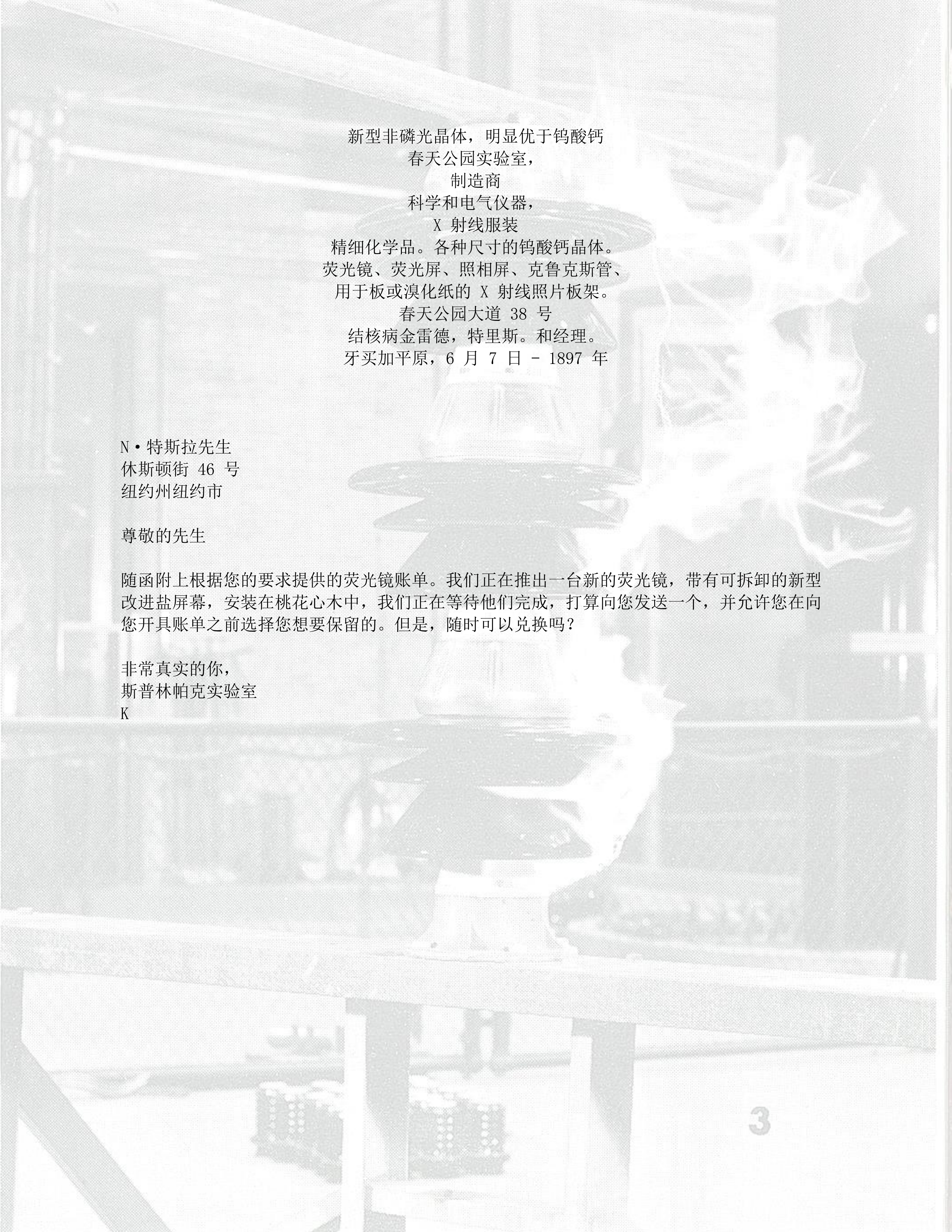
春天公园实验室，
马萨诸塞州牙买加平原

先生们：-

到目前为止，我还没有收到不久前转发给我的荧光镜账单。由于除非您允许我像其他客户一样付款，否则我不可能保留它，因此我恳求您尽快将账单转发给我。

我对其性能感到满意，尽管目前市场上有更好的屏幕，但我仍在使用它。

您非常诚挚的，



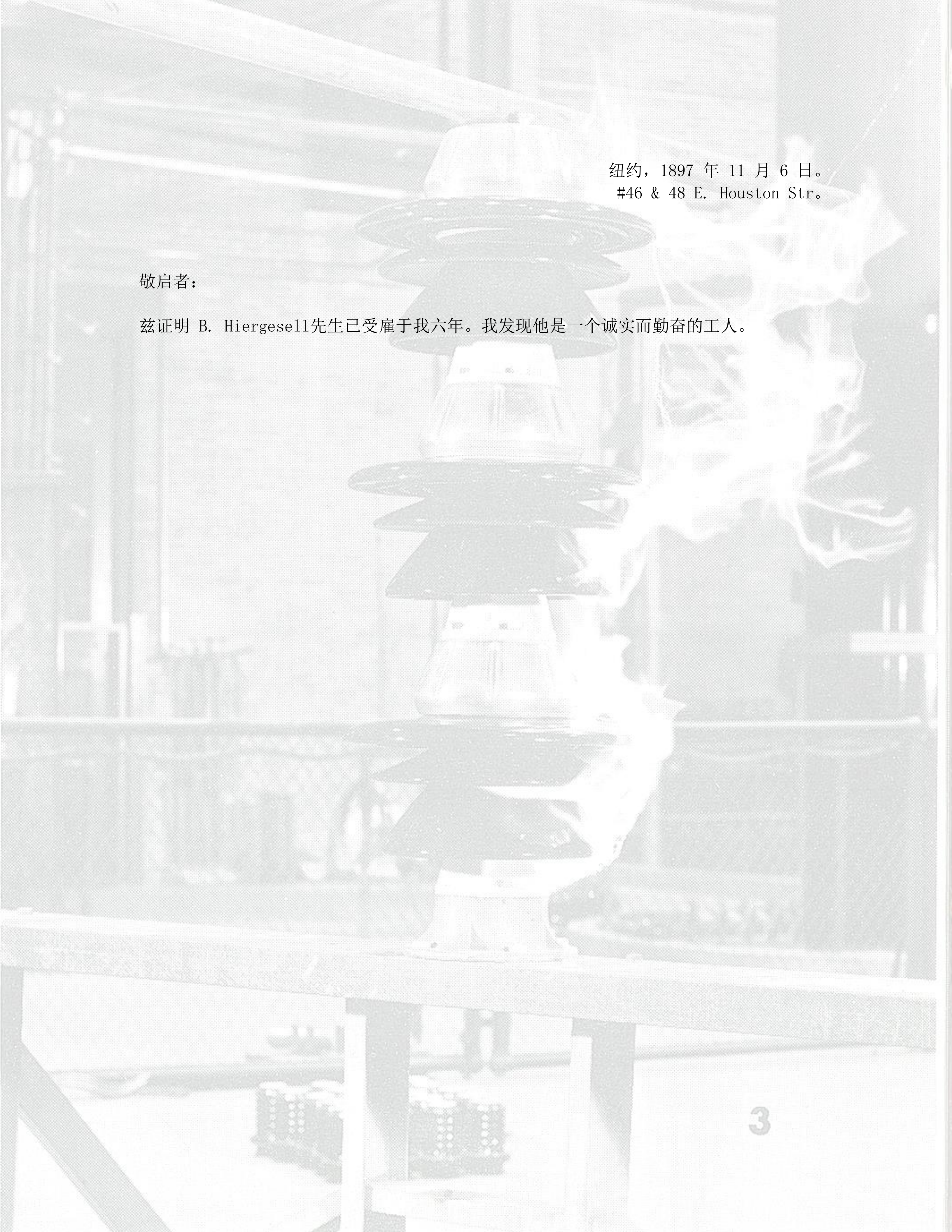
新型非磷光晶体，明显优于钨酸钙
春天公园实验室，
制造商
科学和电气仪器，
X 射线服装
精细化学品。各种尺寸的钨酸钙晶体。
荧光镜、荧光屏、照相屏、克鲁克斯管、
用于板或溴化纸的 X 射线照片板架。
春天公园大道 38 号
结核病金雷德，特里斯。和经理。
牙买加平原，6 月 7 日 - 1897 年

N·特斯拉先生
休斯顿街 46 号
纽约州纽约市

尊敬的先生

随函附上根据您的要求提供的荧光镜账单。我们正在推出一台新的荧光镜，带有可拆卸的新型改进盐屏幕，安装在桃花心木中，我们正在等待他们完成，打算向您发送一个，并允许您在向您开具账单之前选择您想要保留的。但是，随时可以兑换吗？

非常真实的你，
斯普林帕克实验室
K



纽约，1897 年 11 月 6 日。
#46 & 48 E. Houston Str。

敬启者：

兹证明 B. Hiergesell先生已受雇于我六年。我发现他是一个诚实而勤奋的工人。

纽约，1898 年 9 月 26 日。
#46 & 48 E. Houston Str。

文顿先生，
科特兰街29 号
纽约市。
尊敬的先生： -

我已经就高电位高频电流发表了三场讲座，因为这是所有美好事物的数量。

由于我对尸检安排一无所知，因此无法提供必要的信息。

您非常诚挚的，

4 纽卡斯尔法院，
马萨诸塞州波士顿

尼古拉·特斯拉先生，
纽约市。

尊敬的先生： -

作者希望获得一份您的通告副本，该通告的首页以fac形式转载于 1904 年 2 月 6 日的《电气世界与工程师》杂志上。

作者很高兴地记得几年前在东休斯坦街 46 号的旧实验室里见到您。

敬上，

厄尔·L·奥文顿

口授。

奥文顿制造公司
麦迪逊大道 1 号大都会大厦

纽约市

奥文顿
电子治疗仪

电话连接

1906 年 4 月 12 日。

尼古拉·特斯拉先生，华尔道夫酒店，

纽约。

整个泰斯勒

尊敬的先生：-

作者了解到，您正在考虑很快将用于 X 射线和治疗目的的高频设备投放市场。我们专门生产高频机器，并写信询问您是否愿意接受我们公司负责销售或销售和制造您的机器的提议。作者几年前很高兴在您的实验室（东休斯顿街 46 号）见到您，他希望有幸再次相识。如果您在大都会大厦附近，我会很高兴随时见到您，或者如果您愿意与我预约，我将很乐意拜访您。

您非常诚挚的，
奥文顿制造公司。

ELO-N。
厄尔·L·奥文顿，总裁

复制。

TESL AL AB OR ATORY,
Wardenclyffe , 长岛, 纽约

1906 年 4 月 23 日。

奥文顿制造有限公司
纽约州纽约市麦迪逊大道 1 号

先生们：-

你方 4 月 12 日致尼古拉·特斯拉先生的信已正式收到，但他因一段时间以来患重感冒而未能回信。

他指示我写信给您，表示他非常有兴趣收到您的明确建议。您是否愿意将说明您制造的产品的目录副本以及涵盖相同内容的专利说明书副本发送到他的上述地址？

您非常诚挚的，

130 W 84 St
纽约 1910 年 3 月 25 日。

尼古拉·特斯拉先生，
纽约州华尔道夫阿斯托里亚酒店

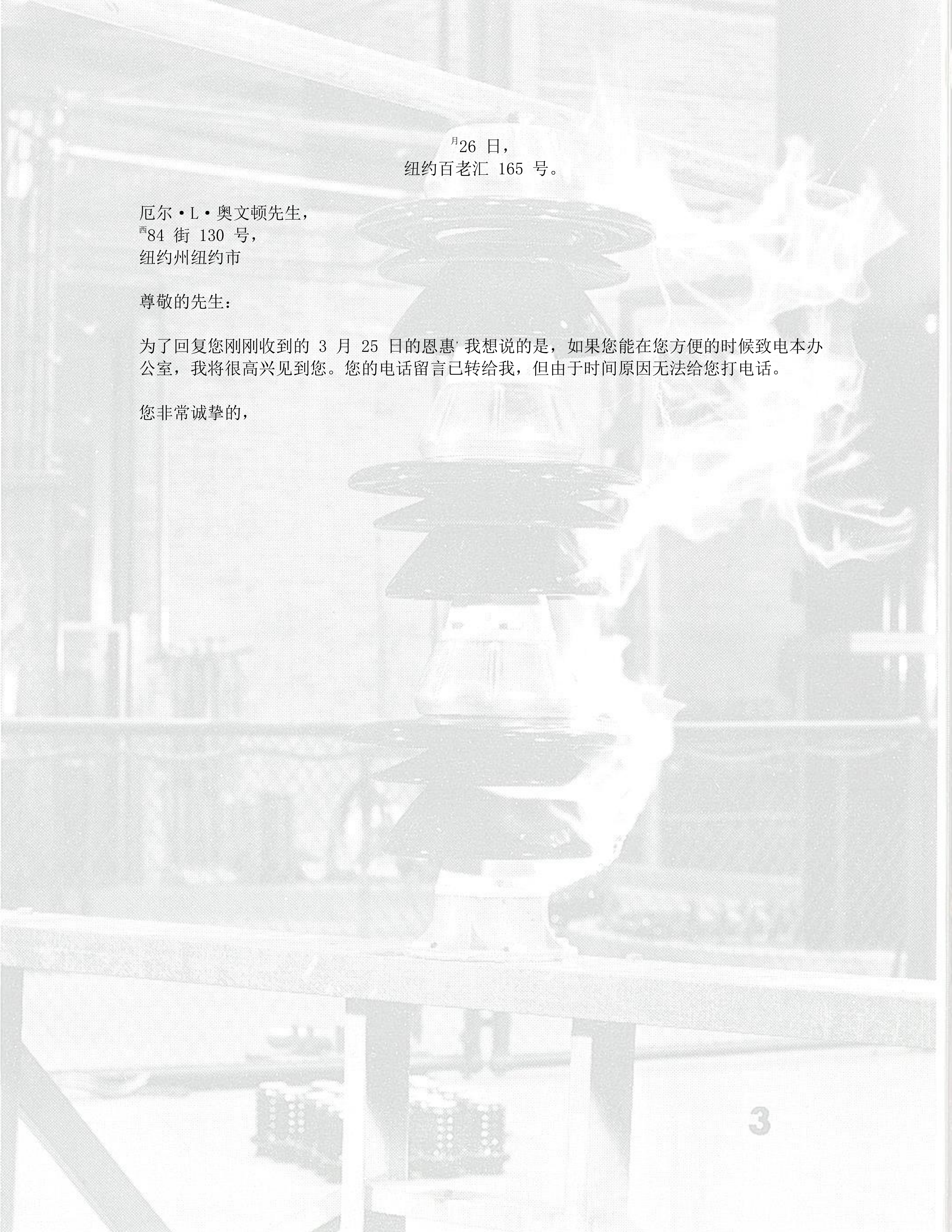
尊敬的先生： -

我要去波士顿，在那里装备一个小实验室来进行一些研究工作。几天后我要离开，我写信询问您是否愿意在我走之前与我预约讨论某件事。我打过几次电话，但你都出去了。

您也许听说过我在各种电展上关于高频的讲座。

非常高兴地期待与您见面，我是，

非常真实的你，
厄尔·L·奥文顿



月26 日，
纽约百老汇 165 号。

厄尔·L·奥文顿先生，
西84 街 130 号，
纽约州纽约市

尊敬的先生：

为了回复您刚刚收到的 3 月 25 日的恩惠' 我想说的是，如果您能在您方便的时候致电本办公室，我将很高兴见到您。您的电话留言已转给我，但由于时间原因无法给您打电话。

您非常诚挚的，

弗雷德里克·F·斯特朗，医学博士，
电疗，
和病理检查。
马萨诸塞州波士顿

亨廷顿大街 176 号。1898 年 9 月 27 日。

先生，-
纽约市。

我亲爱的先生，-

我相信您会原谅我冒昧地写信给您，但我非常渴望得到您对某些问题的意见。在过去的三年里，我一直从事特斯拉高频电流在疾病治疗中的应用的临床研究。 Apostoli和D'Arsonval在这方面做了一些工作，取得了非常显着的成果，特别是在风湿性疾病方面。他们的电流来自特斯拉线圈，该线圈由带有合适电容器的静态机器放电激发。他们使用的电流能够在空气中产生 1 到 2 厘米的火花。我的研究有所不同，因为我使用了自己设计的设备，由大型变压器、油中电容器和特斯拉线圈组成，火花隙是一个旋转的金属板，上面布满了翼，可以移动经过一个固定的球。我使用 104 伏白炽电流，从我的特斯拉线圈中获得约 6 英寸长的火花。

我最近看到了一台具有新颖特征的机器，并制作了一个类似的机器。这是我说过的最好的“X光机”，我很想知道它是否能与我一直使用的机器有类似的治疗效果。该设备已申请专利，我很高兴收到您关于该设备是否可申请专利的意见。它由一个用一磅或两磅 20 号电线缠绕的小火花线圈组成：分为两部分：各部分的末端直接连接到 110 V 直接白炽电流，而各部分的两个内端分别连接到连接到一个由偏心铁盘组成的中断装置，该铁盘通过线圈铁芯的磁性而旋转。该圆盘带有两个与短杆接触的螺柱，短杆在静止时与带有铂端子的柱保持接触。每当螺柱撞击杆的末端时，这种接触就会被破坏。线圈端部连接在一起，一端连接到弹簧杆，另一端连接到柱子。电流被切断，铁盘根据简单电机的原理快速旋转。断口周围连接云母电容器，吸收线圈自感产生的电流。该电容器配备有由特斯拉初级组成的放电电路，该初级由5层1英寸宽的铜箔形成：线圈直径为1英尺。电路中包含一个火花隙，该电路由两块相距很短的铜板组成。

特斯拉次级由一个直径为 1 英尺、四分之一英寸厚的圆盘组成，由一磅 36 号缠绕而成，并嵌入石蜡中。火花线圈消耗半安培电流，特斯拉线圈产生六英寸长的火花。对我来说，这个想法是全新的，我应该很高兴知道它是否可以获得专利。特斯拉线圈中的电流是单向的，火花与火花线圈电路的断路同步。电流是无害的：可以从正极引出六英寸的火花而不会受伤，而从负极端子几乎引不出任何火花。制造商声称它会产生振荡高频电流，但在我看来，频率与火花线圈电路中的断路次数相同。将手放在由机器激发的克鲁克斯管前面会产生一系列图像，就像普通的Rhumkorff的情况一样，这对我来说表明频率很低。请您就以下几点发表意见。

您对高频电流的治疗效果有何体会？

这样的电流需要什么条件才能具有医学价值？

上述机器是否会提供与交替机器（例如我所描述的用于医疗目的的机器）相似的治疗结果？

如果该设备刚刚描述了真正的高频科尔，或者我假设频率较低是正确的吗？ （给电容器充电的电流电压只有3000）

如果您能抽出时间回答这些问题，您将给我很大的帮助，并对我的研究提供很大的帮助。我相信将来某个时候我可能有幸亲自见到您。相信您会原谅我询问信息的自由，并相信我很快就会收到您的消息，我仍然

非常恭敬地，
弗雷德里克·F·斯特朗
#176 亨廷顿大道波士顿

纽约，1898 年 10 月 4日。
#46 & 48 东休斯顿街

Frederick F. Strong 先生，医学博士，
176 Huntington Ave.，波士顿，马萨诸塞州。

尊敬的先生： -

您9月27日的请求已正式收到并记下内容。

我在你的草图中所示的布置中没有看到任何可申请专利的功能。有一个自感应线圈对电容器充电，然后通过感应线圈的初级放电，这是现在众所周知的方案。至于断裂的机械细节，它们同样并不新鲜。

通过取消火花隙，线圈将得到很大的改进，火花隙中必然会消耗一定量的能量。

我无法给你任何频率的概念，因为我不知道电容器的容量和初级线圈的自感，通过它放电。比如说，每秒可能有二十到二十、三十万。当你在真空管的光线下移动手时，你看到的是断裂的基本中断，但每一个中断都可能再次包含大量叠加的快速振动。然而，很明显，由于电容器电流路径中存在火花隙，这些振动很快就会消失，并且其影响非常小。

尽管我对高频电流进行了大量实验，但从医生的角度来看，我无法告诉你它们对身体的影响。在我转发给最近召开的电疗学会会议的一篇论文中，我详细讨论了这个主题，您可能会在我所说的内容中发现一两个有趣的内容。

从机器获得的电流非常突然，我应该说，与提供正弦电流的机器相比，它们不太适合某些电疗用途；至少，人们普遍认为后一种电流更适合用于医疗目的。我不知道这个想法到底是如何产生的，但我认为它很可能是根据早期的观察得出的，即当电流谐波变化时，比电流谐波变化时，更多的能量可以通过患者的身体。是突然的。

关于这个主题，您可能会感兴趣，因为我只是推出了设计大大改进的仪器，这很可能会满足急需的需求。如果您愿意的话，我希望您很快就能购买到这样的仪器，并且我毫不怀疑您会对它的性能感到满意。

您非常诚挚的，

1901 年 7 月 22 日
星期一早上

吉尔德先生，
世纪杂志编辑，-
纽约市。

我亲爱的吉尔德先生，

Thomas B. Kinraide先生在长期实验过程中获得了一些非常出色且有价值的包含放电记录的照相底片。这与迄今为止固定的任何类型的板完全不同。它们展示了其他电力照片从未展示过的一些东西。如果您愿意就该主题与麻省理工学院的克罗斯教授进行通信，他将很高兴向您保证其科学价值。

我想补充一点，该研究所最近接受了Kinraide先生提供的一套约 50 个板块。

我想你可能想在《世纪》中复制其中一些印版——金莱德先生称它们为“电文”。 Kinraide先生选择了一小部分，并好心地允许我写一篇描述性文字，解释它们的含义以及不同的安全条件。

我想您可能有兴趣参观Kinraide 先生的实验室，亲眼看看他在这一领域和其他电气研究领域所做的工作。如果您愿意这样做， Kinraide先生将很高兴欢迎您在那里与 Cross 教授会面。

然后你就能对这些电图的科学价值感到满意，并判断一篇关于它们的文章是否适合“世纪”。

相信您会发现调查Kinraide 先生的工作很愉快，
我是，
非常真诚的您，安娜贝尔·帕克（Anabel Parker）小姐，地址：76 Munroe St. Roxbury, Mass。 Kinraide 的地址是
Thomas B. Kinraide先生。
斯普林公园大道牙买加平原，
大量的。

马萨诸塞州罗克斯伯里
1901 年 7 月 25 日

茹·约翰逊先生，
纽约市。

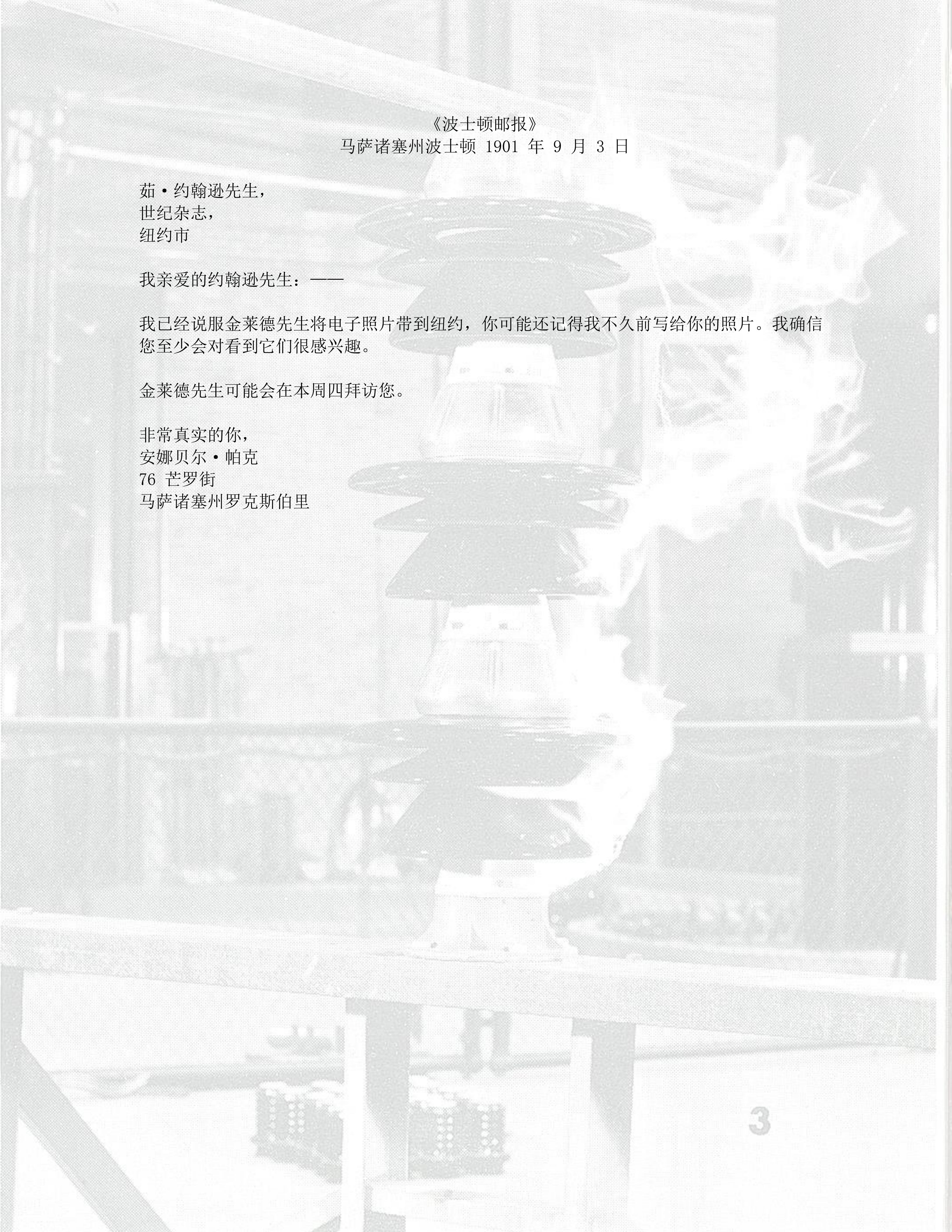
我亲爱的约翰逊先生：——

您已于 7 月 24 日给我回复。

您提到 1890 年 6 月《世纪》杂志上发表的一篇关于特斯拉先生作品的文章。我想您一定指的是 1900 年 6 月刊中发表的那篇文章。那与金莱德先生作品草图完全不同。这是我写的。

一旦我能与刚刚出城的
Kinraide先生取得联系，我就会将照片连同描述性文字转发给他。
同时，金莱德先生和我本人都非常高兴您能与克罗斯教授交流，您无疑对他很有名。

非常真实的你，
安娜贝尔·帕克
76 芒罗街
马萨诸塞州罗克斯伯里



《波士顿邮报》
马萨诸塞州波士顿 1901 年 9 月 3 日

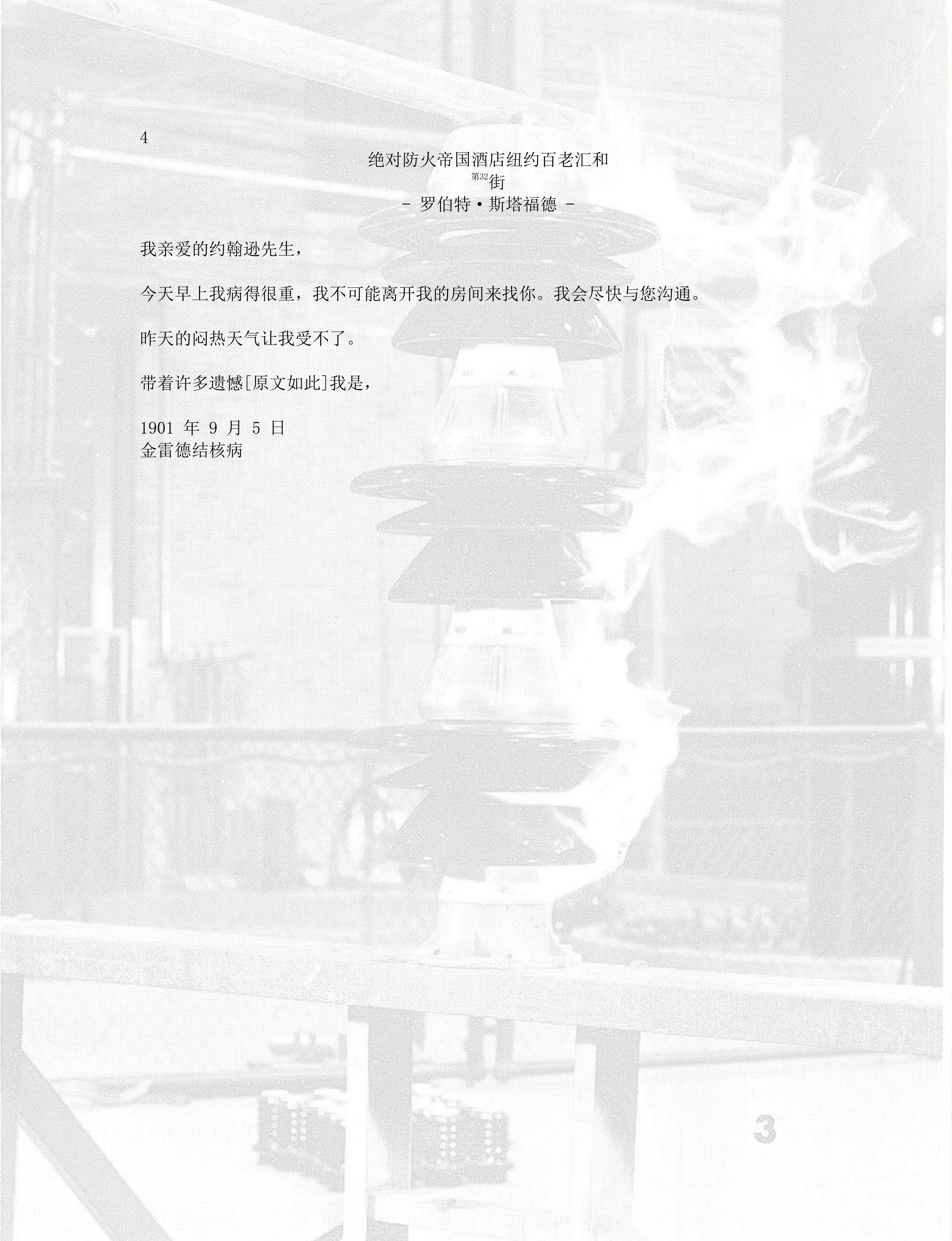
茹·约翰逊先生，
世纪杂志，
纽约市

我亲爱的约翰逊先生：——

我已经说服金莱德先生将电子照片带到纽约，你可能还记得我不久前写给你的照片。我确信您至少会对看到它们很感兴趣。

金莱德先生可能会在本周四拜访您。

非常真实的你，
安娜贝尔·帕克
76 芒罗街
马萨诸塞州罗克斯伯里



绝对防火帝国酒店纽约百老汇和
第32街
- 罗伯特·斯塔福德 -

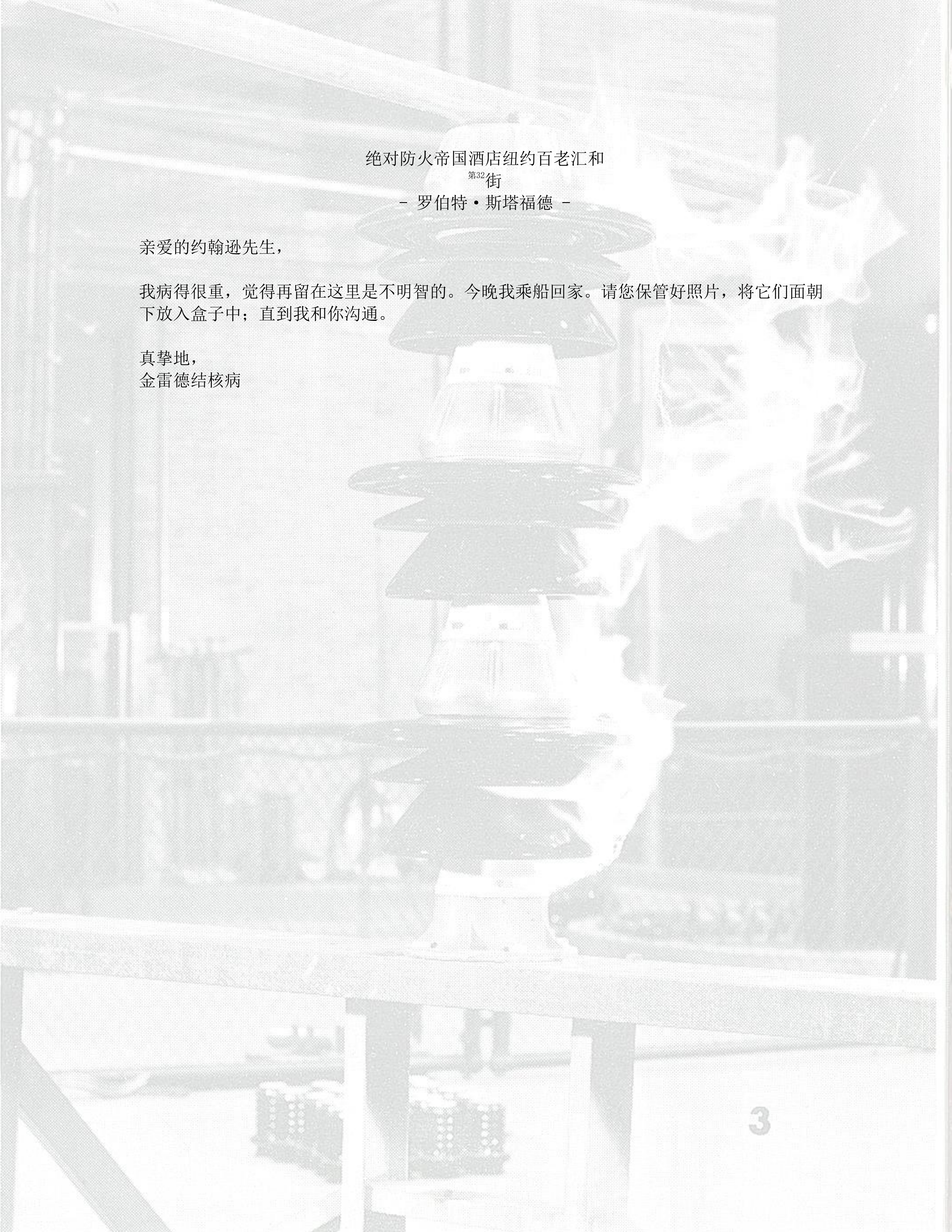
我亲爱的约翰逊先生，

今天早上我病得很重，我不可能离开我的房间来找你。我会尽快与您沟通。

昨天的闷热天气让我受不了。

带着许多遗憾[原文如此]我是，

1901 年 9 月 5 日
金雷德结核病

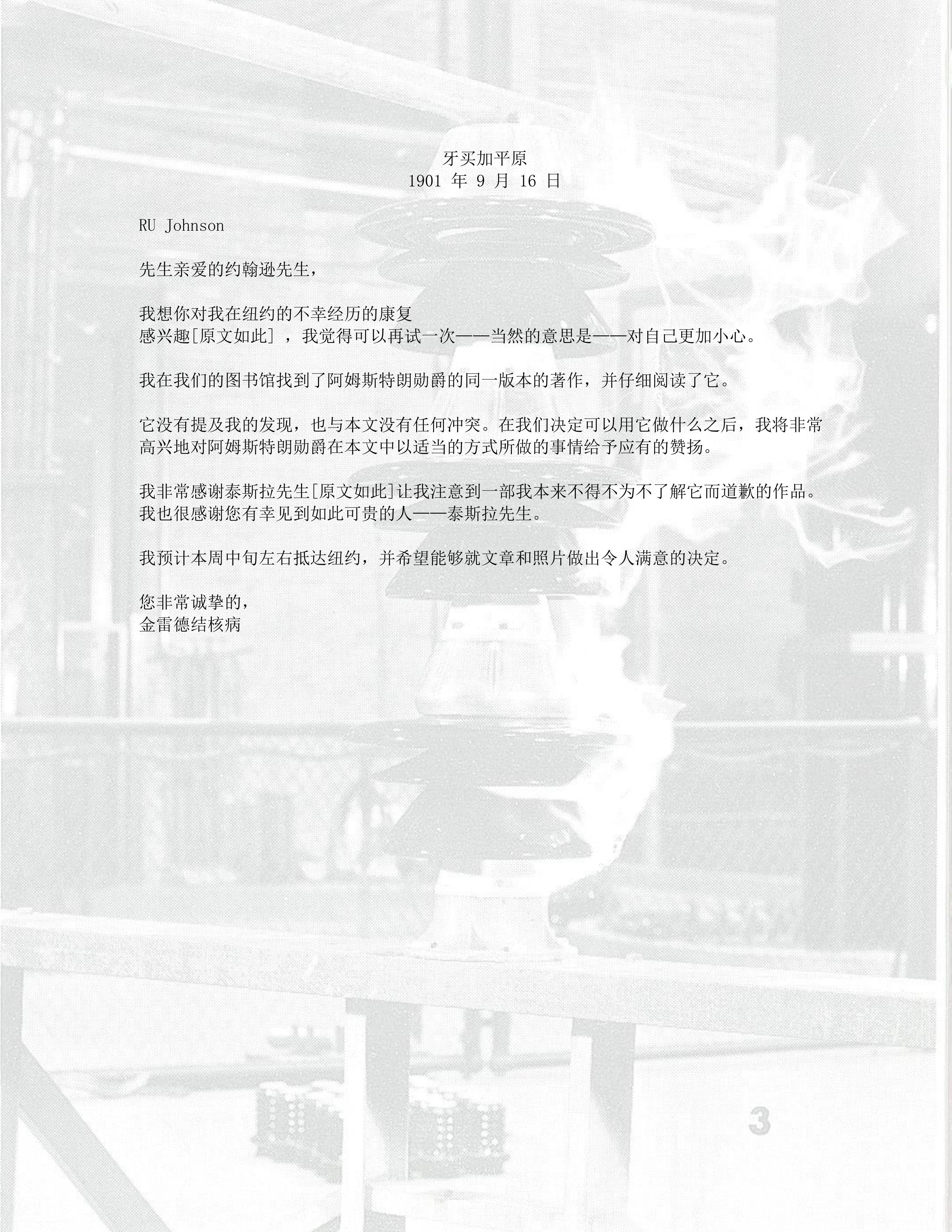


绝对防火帝国酒店纽约百老汇和
第32街
- 罗伯特·斯塔福德 -

亲爱的约翰逊先生，

我病得很重，觉得再留在这里是不明智的。今晚我乘船回家。请您保管好照片，将它们面朝下放入盒子中；直到我和你沟通。

真挚地，
金雷德结核病



牙买加平原
1901 年 9 月 16 日

RU Johnson

先生亲爱的约翰逊先生，

我想你对我在纽约的不幸经历的康复
感兴趣[原文如此]，我觉得可以再试一次——当然的意思是——对自己更加小心。

我在我们的图书馆找到了阿姆斯特朗勋爵的同一版本的著作，并仔细阅读了它。

它没有提及我的发现，也与本文没有任何冲突。在我们决定可以用它做什么之后，我将非常
高兴地对阿姆斯特朗勋爵在本文中以适当的方式所做的事情给予应有的赞扬。

我非常感谢泰斯拉先生[原文如此]让我注意到一部我本来不得不为不了解它而道歉的作品。
我也很感谢您有幸见到如此可贵的人——泰斯拉先生。

我预计本周中旬左右抵达纽约，并希望能够就文章和照片做出令人满意的决定。

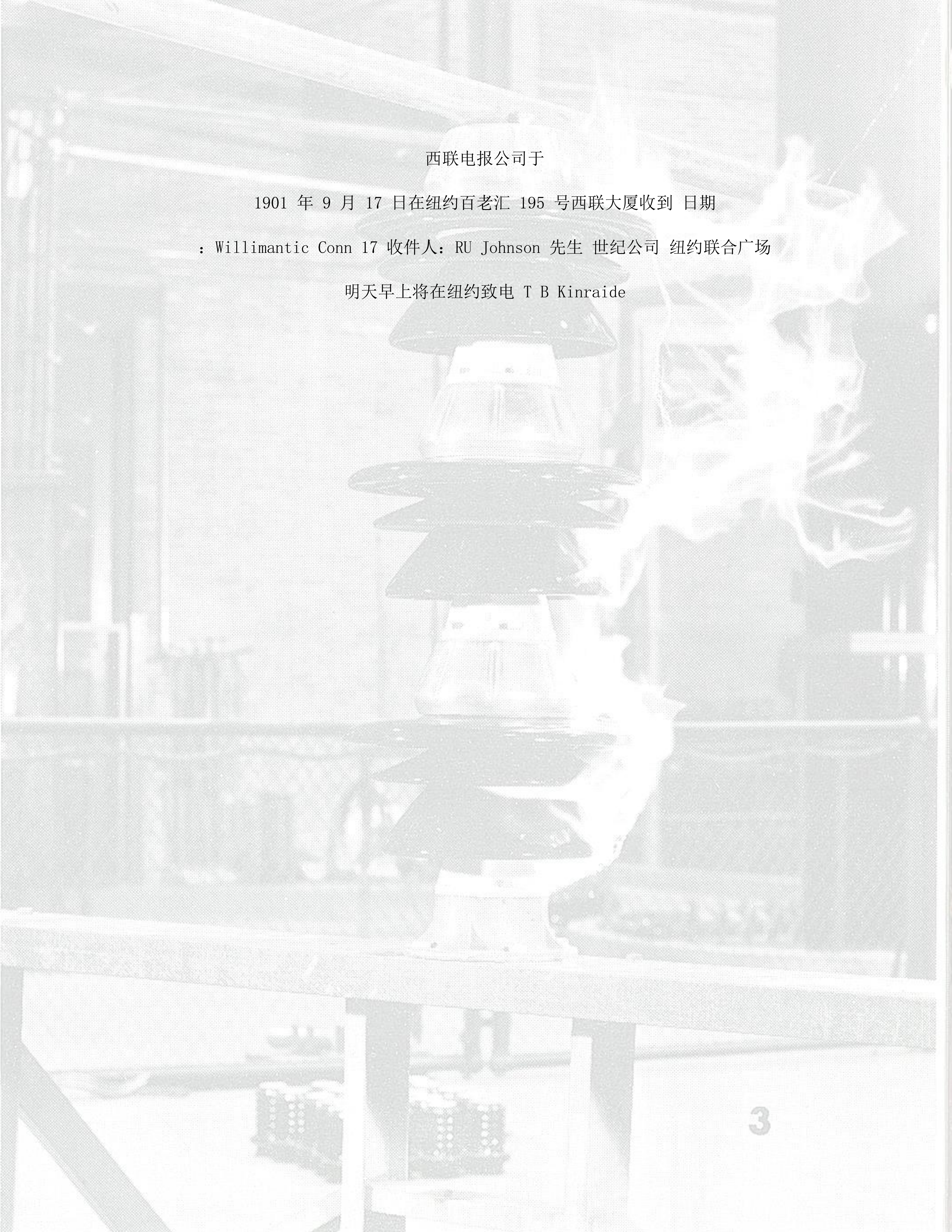
您非常诚挚的，
金雷德结核病

西联电报公司于

1901 年 9 月 17 日在纽约百老汇 195 号西联大厦收到 日期

：Willimantic Conn 17 收件人：RU Johnson 先生 世纪公司 纽约联合广场

明天早上将在纽约致电 T B Kinraide

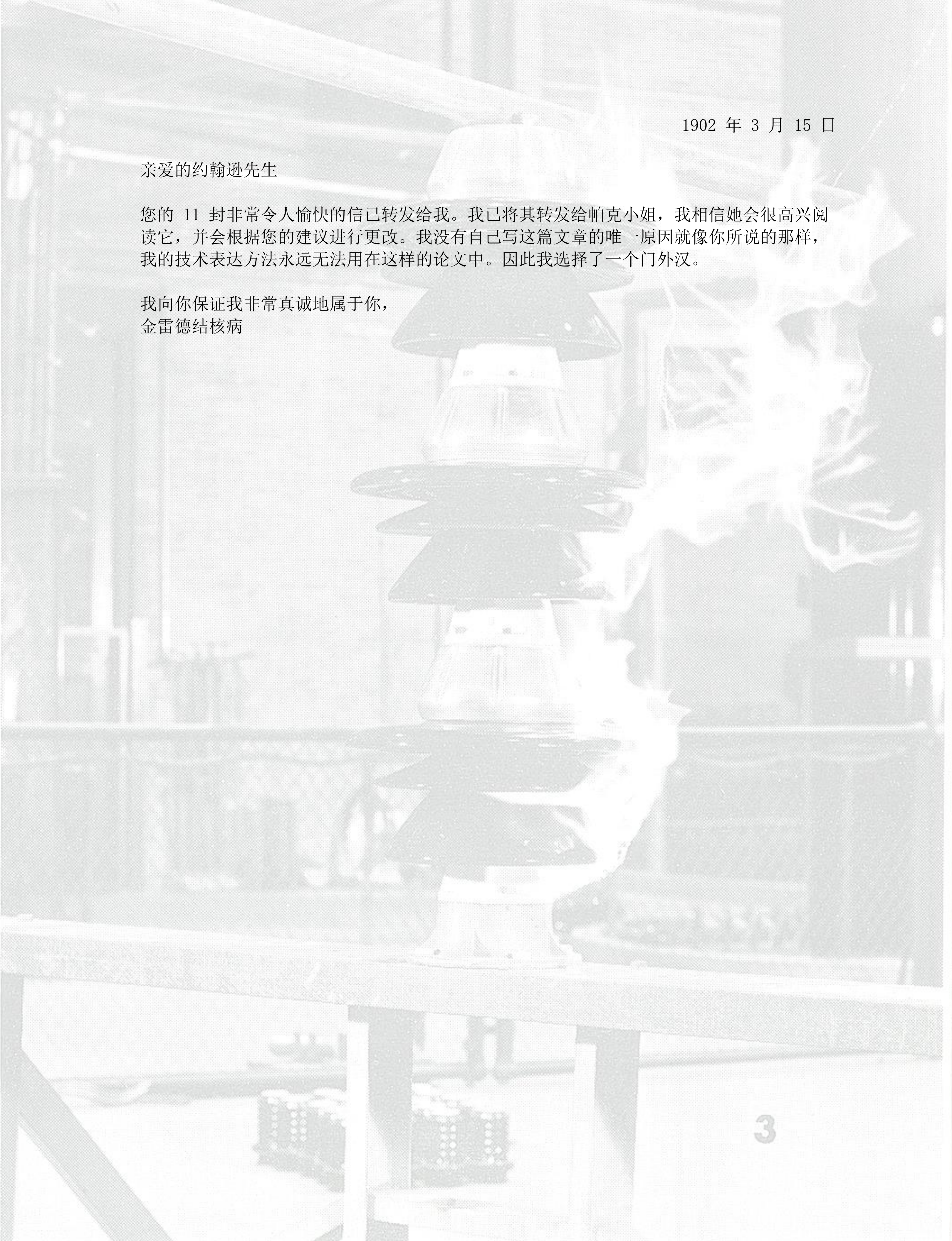


1902 年 3 月 15 日

亲爱的约翰逊先生

您的 11 封非常令人愉快的信已转发给我。我已将其转发给帕克小姐，我相信她会很高兴阅读它，并会根据您的建议进行更改。我没有自己写这篇文章的唯一原因就像你所说的那样，我的技术表达方法永远无法用在这样的论文中。因此我选择了一个门外汉。

我向你保证我非常真诚地属于你，
金雷德结核病



《波士顿邮报》

马萨诸塞州波士顿 1902 年 3 月 21 日

茹约翰逊先生
世纪杂志

我亲爱的约翰逊先生，

金莱德先生已将您关于他的实验的文章的手稿寄给了我。我已经做出了建议的更改，希望现在的副本能够提供。如果您出于空间考虑而希望删除前两段和最后一段，我们不反对您这样做。第 10 页上以“检查一下”开头的段落也可以删除，而不会严重损害文章的目的。如果这篇文章能够被完整使用，金莱德先生和我本人都应该感到高兴。它是经过精心准备和认真渴望使其同时“流行”和科学准确的。我觉得自己深深地感谢金莱德先生的不懈耐心和善良，而且，无论是为了他还是为了我自己，我都应该很高兴能得到良好的空间和化妆。

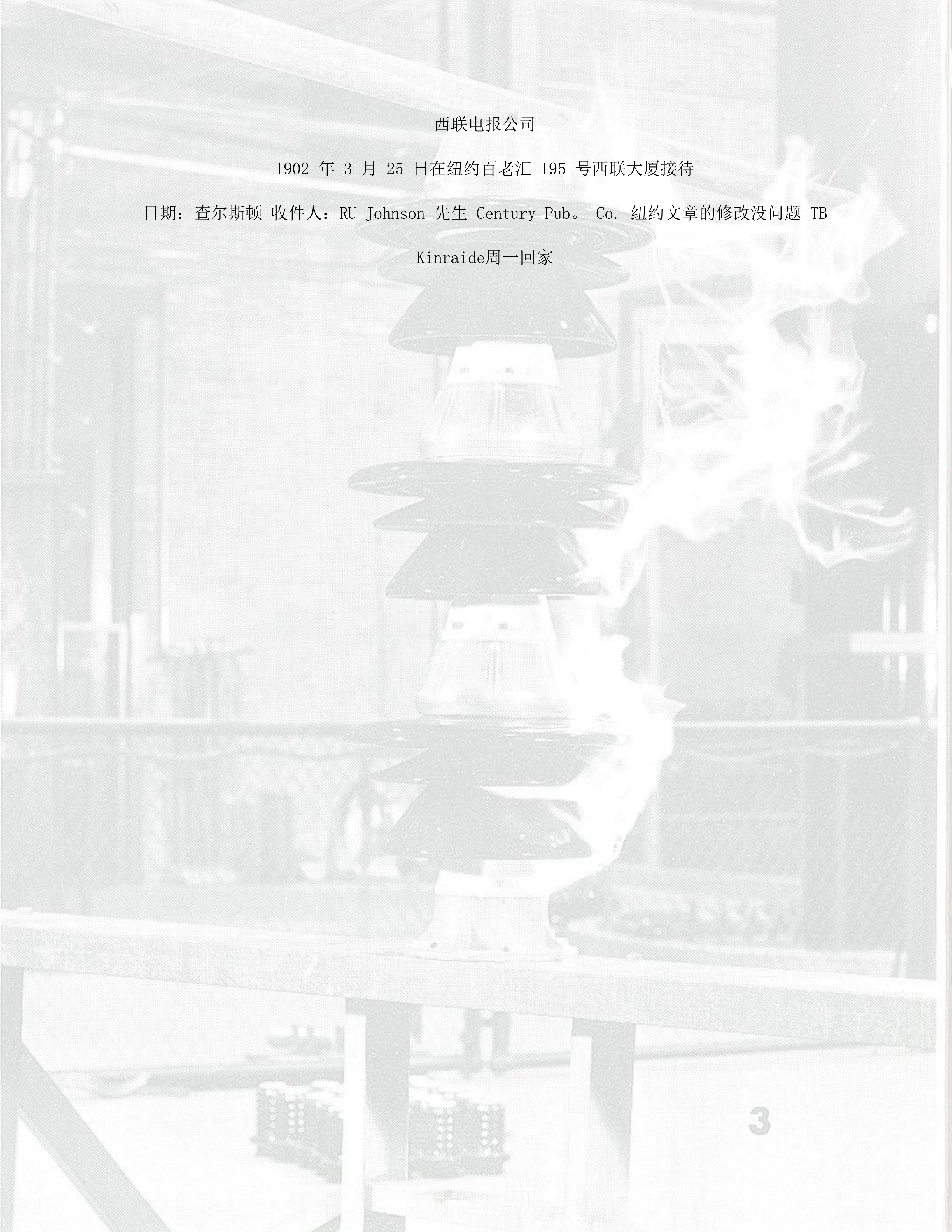
如果您允许的话，我会很高兴看到化妆的样张。

通过这封邮件，我将向现在在佐治亚州萨凡纳的Kinraide先生发送以下重要的更改。我将请他写信或电报给您，表示他们已获得他的批准。

如果您在第二次阅读时发现需要进一步的修改，我将尽力进行修改。我很欣赏你在不熟悉实验工作的情况下就开始讨论这个问题。您最有可能判断它是否足够清晰，足以被普通读者理解。

谢谢你的好意，我真的是你的，

安娜贝尔·
帕克 波士顿邮报 波士顿



西联电报公司

1902 年 3 月 25 日在纽约百老汇 195 号西联大厦接待

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Kinraide周一回家

《波士顿邮报》

马萨诸塞州波士顿 1902 年 3 月 25 日

茹约翰逊先生
世纪杂志

我亲爱的约翰逊先生，

我无法告诉您Kinraide先生在跟我谈论声波照片时是否提到了您提到的 S 教授的作品。---------------- （？）其他一些调查员的。他提到了一个名字，但我现在想不起来了。

我已写信给他，要求就此事与您沟通。他不在南方，这使得这一延误不可避免。

您忠诚的，

安娜贝尔·帕克

《波士顿邮报》

马萨诸塞州波士顿 1902 年 4 月 10 日

茹约翰逊先生
世纪杂志

我亲爱的约翰逊先生，

我必须感谢您提供Kinraide文章的校样，我特此将其退回并更正。

Kinraide先生刚刚加入。他对这篇文章的现状感到满意，并且没有要求进行任何更改。如果非常同意的话，说实话，他会很高兴看到准备好的半色调剪辑样张。

此致，
安娜贝尔·帕克

安娜贝尔·帕克

《波士顿邮报》

马萨诸塞州波士顿1902 年 4 月 28 日

茹约翰逊先生
纽约市,

我亲爱的约翰逊先生，

Kinraide先生指示我说，图 1 下的线应以A_nodos为标题。延迟将证明返还给您是因为Kinraide先生不在家，期间他的邮件没有打开。

金莱德先生要求我对延误表示遗憾。

此致，
安娜贝尔·帕克

安娜贝尔·帕克

《波士顿邮报》

马萨诸塞州波士顿 1902 年 7 月 14 日

茹约翰逊先生
世纪杂志，

我亲爱的约翰逊先生，

我不确定金莱德先生在纽约见到您时是否提到过我在《世纪》杂志7月号上发表的文章的付款问题。然而，我和

Kinraide先生之间达成共识，所提交的所有事项的付款将支付给我。我写这篇文章是为了防止可能出现的任何与此相关的问题，尽管也许这是不必要的，因为您肯定记得是我提交了这篇文章。

感谢您在整个通信过程中的友善礼貌，我是，

非常真诚的你，
安娜贝尔·帕克

安娜贝尔·帕克

办公实践专门提供办公室和住宅，176 HUNTINGTON AVE。
一般疾病 [I11] 下午 2 点至 4 点的高频电流
紫外线治疗皮肤病 电话，后湾 21791

弗雷德里克·F·斯特朗（医学博士）
电疗专家
马萨诸塞州波士顿。

1904 年 3 月 14 日。
尼古拉·特斯拉，
电气专家，
纽约市。

尊敬的先生： -
几年前，当我在波士顿药房经营一家诊所时，专门致力于特斯拉电流的治疗用途，我写信给您询问与我的工作相关的某些技术细节的信息。您非常友善地回复了一封私人信件，在信中您充分解释了我写信给您的要点，并表示您愿意在我去纽约时见到我。
在过去的十年里，我一直在实验和应用高频电流，并设计和完善了许多用于医疗工作的仪器。在这方面，我受邀于3 月18 日下周五晚上在纽约物理治疗学会演讲。我的设备制造商正在向我发送一台供我使用，我将尽力通过实验演示高频电流的现象以及将它们应用于治疗疾病的方法。
我长期以来一直希望能亲自见到您，看看您的一些作品，如果您愿意接待我，并附上您的地址和对您来说最方便的时间，我会在某个时候拜访您18号，星期五。如果您周五不能见我，周六可以方便的话，我将很高兴再多呆一天，以便利用我长期以来渴望和热切期盼的机会。
相信您可能会同意我的请求，我是，
非常恭敬地，
弗雷德里克·F·斯特朗

口授。

新罕布什尔州西林奇，1906 年 7 月 17 日。

尼古拉•特斯拉，
纽约华尔道夫酒店。

尊敬的先生： -

雷布曼公司在接下来的秋季出版。
作为这种奇妙电力形式的先驱和创始人，我自然地请求您的帮助。如果您能向我发送您关于该主题的各种出版物的参考资料，如果可能的话，您手头可能有任何重印本，我会很高兴。
我相信，关于高频电流作为治疗剂可能具有重要性的最初建议来自于您本人，尽管有关该主题的文献将达松瓦尔视为高频治疗学的先驱。如果您愿意向我推荐有关该主题的一些已发表的声明，我会很高兴，我可以在我的书中引用这些声明，以满足我一直对您在这方面的工作的优先权提出的要求。如果您能寄给我一张您的照片，我也会很高兴，以便我可以将其合并到书中。
在过去的十年里，我的工作一直致力于特斯拉电流用于治疗目的的应用和研究，这与欧洲当局使用的达松瓦尔和奥丁电流形成鲜明对比。我相信，与任何其他形式的高频电流或所使用的任何其他形式的电相比，您的电流具有更大范围的治疗价值，并且对当今的医学界更为重要。为了彻底证明这一点，让业界满意，需要您的配合。当然，对于您给予我的任何帮助，我将表示衷心的感谢。
预先感谢您，并相信我会得到早日答复，我仍然，

非常诚挚的您，
FF 斯特朗，医学博士
FFS/ED

1906 年 7 月 23 日

FF·斯特朗博士，
新罕布什尔州西林奇
我亲爱的斯特朗博士：-

我注意到您在 7 月 18日提出的请求，并很乐意尽我所能在此事上为您提供帮助。我首先请您注意我发表的有关高频的出版物。不幸的是，我没有这些文件的副本，但以后也许可以找到一两份并发送给您。

1890 年 9 月 12 日，《伦敦电工》杂志上有一封关于我制造的高频交流电机的信，我相信，这是第一台高频电机，也是第一次提到高频工作。

标题为“关于甚高频交流电的注释”的文章《电气工程师》（纽约）1891 年 3 月 11 日，《电气世界》，1891 年 3 月 4 日。

作为高频交流电的参考，1891 年 4 月 1 日的《电气工程师》和1891 年 4 月 17 日的《伦敦电气评论》，也参考了 1891 年 4 月 3 日的同一评论。

有一篇“关于高频电流现象的讨论”，电气工程师，1891 年 4 月 22 日。真空管放电实验，电气工程师，1891 年 6 月 24 日，伦敦电气评论，1891 年 7 月 10 日。

Alt 的生理效应。高频电流、电流。世界，1891 年 3 月 4 日；电气。工程师，1891 年 3 月 11 日；伦敦电力《评论》，1891 年 3 月 21 日；《伦敦电工》，1891 年 8 月 19 日。

关于替代的注释。变频电流，伦敦电工，1891 年 3 月 20 日。
甚高频交流电现象，电气。世界，1891 年 4 月 4 日，也是电气世界，1891 年 4 月 25 日。

高频放电感应，电。世界，1892 年 2 月 20 日，Elec。工程师，1892 年 2 月 17 日，伦敦电工，1892 年 3 月 4 日评论，1892 年 3 月 18 日。

冷凝器、火花和空气喷射、电气的进一步实验。《世界》，1892 年 2 月 27 日，《伦敦电气评论》，1892 年 3 月 25 日。

高电势和频率下的动态感应，电气世界，1892 年 4 月 2 日，电气评论，伦敦，1892 年 4 月 15 日。

高频电感应，在艺术协会之前阅读的论文，波士顿，技术季刊，卷。 6，第 1 号，1893 年。

赫兹波的奇怪效应，电。工程师，1894 年 7 月 4 日。

《论实验室和电镀厂中的赫兹波》，伦敦电工，1894 年 7 月 13 日。

关于高频电流通过身体的影响的注释，电气。工程师，十月1894 年 10 月。

交变电位下油的介电强度，电气。工程师，1896 年 2 月 12 日，Elec。世界也，同样的日期。

高压下的电力。纽约电气学会演讲，1899 年 3 月 29 日。以小册子形式出版，我想我可以给您寄一份小册子。

获取高频和压力的装置，《电气世界》，1899 年 10 月 14 日，《电工》，1899 年 11 月 3 日。

当然，如果不比较早期实验的日期来解决优先级问题是不可能的，因为没有进行过这样的比较，但你会在“高压电力”小册子中找到对教授的一些实验的参考。约翰·霍普金斯大学的罗兰的研究确实涉及从一组匝到另一组绝缘的高频感应原理。约瑟夫·亨利（Joseph Henry）在很多年前也提出过由莱顿瓶和电容器放电引起的相邻电路中的电流，亨利首先指出了莱顿瓶放电的本质。我相信我是第一个对空芯线圈进行研究的人，即没有任何铁芯，用于产生高频感应，除了亨利实验和罗兰实验涉及相同的想法。我相信，我是第一个在冷凝器火花上使用空气喷射来增加振荡锐度的人。除了这些事实之外，并且没有对日期进行任何适当的比较，就不可能做出任何其他声明。

毫无疑问，特斯拉先生很早就参与了这项工作，而且可能是先行者，但我认为他无疑是先行于这项工作的某些功能的。然而，我认为，在您正在准备的工作中，最好仅参考已发表的论文和描述，在没有其他数据的情况下，这些论文和描述必须成立。事实上，我非常不喜欢就这一点发表任何声明，因此请您将我上面所说的内容视为对您个人的帮助，而不是发表。你会发现，在事物的本质上，没有权威性陈述的标准。

如果可以的话，我会尽快转发照片。

您非常诚挚的，

伊莱休·汤姆森。

PS 我正在向您发送一份有关“高压电力”的小册子。

1954 年 10 月 15 日

特斯拉对我们来说就是“尼克”，因为我已故的父亲有幸为他的百万富翁支持者开出支票，这些支持者拥有奥康尼特电线电缆公司，并通过将曼哈顿岛的电话权出售给纽约电话公司而获得巨额利润。公司售价约 17,000,000 美元。这是一笔免税交易，这笔金额在当时是相当大的一笔。他们通过英国集团向马可尼提供贷款，并部分资助了费森登、德福雷斯特和许多其他科学界鲜为人知的机构。特斯拉是他们的“问题发明者”。

他们并不是唯一一个与他有困难的人，因为摩根大通的长辈总是把尼克当作他的宠物问题。我曾在摩根富丽堂皇的蒸汽游艇“海盗船”上担任安装工程师，曾短暂为他工作过；我还为参议员纳尔逊·W·奥尔德里奇在他的获奖蒸汽游艇阿尔维娜号上担任测试工程师，担任过世界各地的测试工程师。两人都有影响力。即使是借给特斯拉现金购买机器人的老约翰·海斯·哈蒙德也无法理解这个奇怪的天才。

爱迪生曾试图以他的冷静和直率的方式与特斯拉交朋友，但他的言论被极其敏感的特斯拉视为一种侮辱。凭借典型的欧洲-斯拉夫绅士风度观念，他在无线电和电力先驱的混乱领域中是一个奇怪的人物。他遇到的大多数科学家都是好朋友。有些是拍背式的，如爱迪生、费森登、马可尼、德福雷斯特、弗莱明、普里斯、洛奇、斯拉比、泽内克和西利格。老纽约游艇俱乐部的成员包括摩根、盖茨、洛克菲勒、利特、戴维森、卡彭特、贝内特以及其他许多我父亲非常熟悉的人，他们都是同一级别的人，但在友善方面可能要克制一些。

我认识这些人，并回应了他们善意的绰号“无线人约翰”，这个头衔让我很高兴，因为我喜欢制造火花并创造壮观的高频展示。尼克是一个安静、好学、非常得体、弯着腰、举止得体的欧洲日耳曼人（斯拉夫人），似乎从来都不太适合粗俗的美国环境。他看起来就像一个与众不同的人——一个相当内向的人。再加上他对不握手和以特殊的卫生方式进餐的奇怪恐惧症，使尼克成为一个引人注目的人。许多人认为他是一个普通的势利小人。其他人称他为“坚果”，而另一些人则称他为“天才”，并且总是为他的行为找借口，煞费苦心地解释说这是天才所应有的。

那些为尼克工作的人很少得到他的信任。他的草图总是分成几部分。他的记录从来都不完整。他害怕盗版。他被盗版了，令人遗憾的是，一个以自己是原理的发现者而不是发明家为由拒绝诺贝尔奖的人竟然被他的同时代人如此盗版、谎言和抹黑。他们采纳了他的想法，并愉快地继续着，就好像特斯拉的发明是免费财产一样。

Ovington ）的布莱利奥特单翼飞机上安装了我的原始系统，并使用第一根地网天线，与像奥文顿伯爵这样的人相形见绌。当伯爵在米尼奥拉-亨普斯特德上空约 1500 英尺高空翱翔时，我们携带了第一个从飞机到地面的双向无线电。他成为第一批航空邮件飞行员之一。奥文顿是百万富翁的儿子，也是特斯拉的密友。

厄尔在老麦迪逊广场花园的乌鸦上方的平台上安装了一个巨大的特斯拉线圈，展示了壮观的烟花表演。他会让我在玻璃平台上冒险，从我手里的魔杖上擦出可怕长度的大火花。我很快发现，我们在电气表演期间每天都有日场和晚间演示，吸引了大量人群，他们希望看到我们俩都被电死。厄尔很爱炫耀，他很喜欢这样。尽管我对我所爱的火花着迷，但我还是一个害

怕的孩子。特斯拉会站在一旁，以慈父般的目光注视着我们俩。特斯拉在他的实验室为百万富翁朋友举办聚会。尼克喜欢把灯光调暗并进行怪异的展示。我必须承认，我多次尝试效仿他，这很有趣。

我的第一个任何尺寸的无线发射器是一个 10 KW 开芯变压器，我有一个开放间隙和一个巨大的油中玻璃板电容器。当我在大西洋中部的船上工作时，利用扬克斯上空的巨大天线，我可以获得令男孩们羡慕的距离。 1912 年之前，不需要许可证。空气是免费的，我们拓荒者确实享受到了如今没有人能够理解或想象的乐趣。

随着年龄的增长，尼克变得非常奇怪。我的老朋友路易斯·帕坎特（Louis Pacant ）曾经拜访过特斯拉。路易斯是一个聪明的男孩，他在美国各地签约了 900 多家音响剧院。当西方电气公司发现自己被击败时，他们给了路易斯丰厚的回报。他很享受这一点，因为作为一个贫穷的纽约男孩，他在布鲁克林的普拉特打工，他从与“大男孩”的接触中获得了乐趣。作为一名文静、谨慎的咨询工程师，他很快就发现尼克是他的同伴。他们会在尼克的顶层公寓聊天，但路易斯却能聊这么远。尼克具有独特的保守和怀疑态度，这使他成为一个独特的人物。没有人比路易斯更接近了。

我可以在这里闲逛很多。我已经完成了一部关于广播历史的纪录片，正在制作另一部关于我的老同学霍华德·阿姆斯特朗的纪录片，我帮助他提出了第一个反馈想法，并在他的父亲拒绝支持他后，协助他在扬克斯获得了第一个专利。

我希望你们能在科学教师中建立某种东部特斯拉俱乐部，目的是让年轻一代了解特斯拉发现的一些兴奋之处。我希望看到特斯拉协会每年为一些有价值的科学成就颁发奖章。

不幸的是，言语完全不足以表达年轻人追求宠物爱好时的兴奋。我对电子产品的追求如此之多，以至于我很遗憾无法用语言来表达那些巨大的兴奋，以公正地描述多年来的惊奇和难以形容的兴奋。

诚挚的，

约翰·奥利弗·阿什顿

加利福尼亚州帕洛阿尔托

[约翰·奥利弗·阿什顿信件摘录]

在东方有一个人，如果你能正确接近他，他可能会帮助你。他是小约翰·海斯·哈蒙德 (John Hays Hammond Jr.)，一位在马萨诸塞州格洛斯特患病的百万富翁。他的父亲是特斯拉机器人的支持者。我认识很多百万富翁，但这个是个势利小人。

1910 年，我与厄尔·奥文顿 (Earl Ovington) 等人结识，在他的 Bleriot 单翼飞机上，我使用第一条地网天线安装了我最初的系统，当厄尔 (Earl) 在米尼奥拉-亨普斯特德 (Mineola-Hempstead) 上空约 1500 英尺高空翱翔时，我们携带了第一个从飞机到地面的双向无线电，我在扬克斯的“总部”，伯爵驾驶着他的“飞行器”高空飞行。他成为第一位航空邮件飞行员。他是百万富翁的儿子，也是特斯拉的亲密朋友。

厄尔会使用安装在老麦迪逊广场甘登乌鸦上方平台上的巨大特斯拉线圈来表演壮观的烟花表演，当他让我在玻璃平台上冒险时，我拿着的魔杖会产生可怕长度的大火花。我的手又跳到特斯拉线圈顶部的球上。我很快发现我们在电气表演期间每天都有日场和晚间表演，吸引了大批观众，他们希望看到我们俩都触电。厄尔很爱炫耀，他很喜欢这样。尽管我对我所爱的火花着迷，但我还是一个害怕的孩子。

特斯拉会站在一旁，以慈父般的目光注视着我们俩，并微笑着，因为正如你所读到的那样，他本身就是一个表演者。他在实验室为他的百万富翁朋友举行的著名派对非常有名，尼克喜欢把灯光调暗并进行怪异的展示。我必须承认，我多次尝试效仿他，这很有趣。

我的第一个任意尺寸的无线发射器是 10 KW 开芯变压器，我在油冷凝器中有一个开放间隙和巨大的玻璃板。当我在大西洋中部的船只上工作时，利用扬克斯上空的巨大天线，我可以获得令男孩们羡慕的距离。 1912 年之前不需要许可证。

2007 年 2 月 2 日

你好，

在做一些家族史研究时，我偶然发现了你发布的我父亲 1916 年出版的书《高频设备》。

不用说，我完全不知道你和你的活动；关于他参与高频设备的日子，我们有各种家族传说，但可证实的事实却很少。如果您有任何可以提高我对那个时期的了解的信息，我将非常欢迎。像许多有过这种过去的人一样，尽管我和我的兄弟恳求他，他还是不愿意分享他的记忆。

我的祖父（也是同名的）是新泽西州北部的一名医学博士，他是 X 射线医学的早期研究员，并且传说是最早应用高频交流电来激励 X 射线管的人之一。他于 1904 年去世，留下了我 15 岁的父亲对电气工程的兴趣和知识，这让他开始了与电力相关的职业道路，让他忙碌了 35 年。

在此早期，他从一个 15 岁的新泽西州来到波士顿，在那里他有一个足够复杂的实验性交流实验室，引起了麻省理工学院的兴趣，用它来补充他们的直流设备，然后又去了纽约，在那里他有一个交流实验室。 1917 年，应用研究实验室于 1917 年出版了这本书。该书的出版是在出版

“自己动手”电气工程杂志（据说对《大众科学》杂志的创建具有影响力）的几年计划之后进行的。该实验室及其全体工作人员被“征召”到美国化学战部门。1917年到部队从事电炉生产防毒面具原材料工作。

他这 12 年的活动相当“灰色”，因此您可能拥有的任何线索都会有所帮助。

我去佛罗里达的机会不大，但我很想参观博物馆。当我还是个孩子的时候，我确实玩过火花线圈，并且正在收集从未接近完成的范德格拉夫发电机的零件。它在基因中，不过。

KR

汤姆·柯蒂斯

2007 年 2 月 3 日

你好，杰夫，

这很令人兴奋，不是吗？

我父亲最早的照片可能是 20 年代初期或中期的照片，当时他在退伍后搬到了加利福尼亚州洛杉矶。此时，他正在建立一家生产定制耐火材料的企业，使用电炉来制造他的企业赖以建立的“新”合成化合物。当我有机会时，

我需要深入档案以找到要发送的图片。您可能有机会通过其他研究手段找到 1916/1818 年的资料：我记得小时候看到一张旧的棕色轮转凹版报纸插页中的一页，很可能来自《纽约时报》，其中一页是“年轻”的照片正在帮助战争的工程师。”在这个页面上，爸爸与爱迪生、马可尼、特斯拉和其他一些人一起合影。我真的不确定是谁在里面，但爸爸在一家非常重要的公司工作。我记得爸爸的照片比爱迪生的要小一些，但它就在那里！

书：我从未看过第一版，所以我很高兴有你的努力。我确实有一份 1920 年第二版，由 Raymond F. Yates 编辑。根据第二版序言，耶茨所做的唯一一件事就是添加了一些相关的 1917 年杂志文章并删除了供应商源材料，因为柯蒂斯工程实验室已经消失。 （爸爸绝对不是耶茨的粉丝，出版商把他推向爸爸的新版本，因为爸爸正忙于赢得战争）。

杂志：我收藏了一小部分《日常机械》杂志，该杂志在第 1 卷和第 2 卷之间演变为《日常工程》。 2 No 5 和 Vol。 2 No 6，不是完整的一套（已出版的 18 套中的 12 套）。我有卷的副本。 2 第 1 卷和卷。 2 No. 2，我想寄给您供您的博物馆使用。我应该把它们送到哪里？设备：我不知道柯蒂斯祖父从哪里得到了用于

X 射线工作的高频设备。乡村医生从头开始工作似乎有些困难；实验人员对自己和患者造成了可怕的辐射烧伤，直到有人偶然发现高频产生的 X 射线是“软”的并且不太可能烧伤（不同频率？）；爸爸告诉我们，他的父亲通过一只

没有杀死病人的手臂拍摄了第一张照片。

我不知道父亲去世后，父亲是如何或为何来到波士顿的。一定
是与生意有关（上面没有家人）；是你在弥撒中提到的设备供应商，他是否一直在追寻
他父亲使用过的设备

的踪迹？
联系方式：我不可能去佛罗里达的原因是我住在
加利福尼亚州萨拉托加（靠近圣何塞，旧金山以南 40 英里），
距离很远！所以我们最好依靠电子邮件、电话或其他方式。电话号码
是 408 867-3541。电话联系可能最好在晚上进行，除了
我安排会议的第三个周三和周四。太平洋时间 6:30 到 10:30 之间的任何时间都
可以。如果我在第三次响铃
时没有接听，请不要让它进入答录机，除非它很重要（节省你的
美元）。

KR

汤姆·柯蒂斯

2007 年 2 月 10 日

你好，杰夫，

有个好消息！

我哥哥在他的档案中找到了报纸版面，上面有 TSC 和
爱迪生等人的照片。上面的日期是 1917 年 4 月 29 日。实际上，
他发现的物理内容与我记忆中的（他的记忆也是如此）不完全一样
，但实质内容正是我们正在寻找的内容，因此可能还有另一个
版本尚未出现。无论如何，一旦我们找到
重现它的方法，我就会给你一份副本。使用的字体相当小
，页面是中心跨页，尺寸相当大。它需要以
相同的尺寸复制。这使得复制成为一个挑战。
我会随时通知您。

希望您的北上之行圆满成功。

KR

汤姆·柯蒂斯

2007 年 2 月 13 日

这些照片没有引起任何警觉。 “海象”式的小胡子从来都不是他的
风格。从早期到结束，我只记得一种修剪整齐的小“军装”风格。
（我记得最早的图片可能是
1916年-18年的）

从我所看到的奥文顿的时间线来看，我认为它们没有
明显的重叠。其中提到他曾为爱迪生工作过——
那是什么时候？爱迪生什么时候与 X 射线合作导致他的助手死亡？
请记住，爱迪生主要是一个直流电人，而爸爸总是使用交流电，
除了电池供电的电机等，因此
据我所知，当时不太可能进行“友好”接触。

KR

汤姆·柯蒂斯

2007 年 9 月 13 日

一定是心灵感应——过去
几天我一直在想给你写信。

在过去的几个月里，
我和我的兄弟一直在为这个家庭做一些认真的家谱工作：他站在母亲一边，主要是因为我的
祖父是挪威人，他的妻子是挪威人——应该会让事情变得
容易一些。我有柯蒂斯的一面，主要是因为作为最大的男孩，
我姨妈觉得她有责任让我的头脑充满家族传奇（
我的研究对其中许多传奇产生了严重怀疑）。

我有一个严重的空白需要填补，也许凭借您对
那个时代技术发展的了解，您也许能够指出一些
可以遵循的道路。让我来介绍一下场景，以便您可以建设性地思考。

我的祖父（也是同名的）是新泽西州北部的一名乡村医学博士，他
与纽约市的哥伦比亚医学中心仍然有一些联系（他可能是一名
毕业生，尽管我还无法证实这一点。他是
医学领域的早期实验者） X射线；他是如何开始使用
高频交流电作为激励源的，事实证明，这种交流电产生的
波长比常用的火花线圈的致命波长要小（没有任何线索表明
这是如何发生的，但逻辑告诉我可能是
直接或直接通过哥伦比亚大学进行的）。

他于 1904 年 12 月突然去世，留下了 14 岁的托马斯·斯坦利（Thomas Stanley），他可能已经参与了这项实验工作好几年了。

这个庄园基本上让我的祖母和两个分别为 14 岁和 11 岁的孩子流落街头，身无分文。在 1900 年的人口普查中，他们和祖母的母亲住在一起，她比我祖父早一个月去世，而祖父去世时没有留下遗嘱；这肯定是对于律师来说是一笔财富，而对于祖母来说却是一团糟（她是被“淑女”抚养长大的，可能不知道如何保护自己）。

这个小家庭消失了； 1910 年的人口普查中没有发现他们的踪迹。爸爸常常说起祖母试图靠兜售祖父处方药膏和药膏为生的化妆品、住在寄宿屋等。

不知何故，1904 年这个 14 岁的男孩把自己变成了一位公认的空调设备制造专家，并保持1914 年，当他 24 岁时，他的母亲和妹妹还活着。这段时间他至少有一部分时间在波士顿/剑桥地区。他谈到他借给麻省理工学院的交流设备，因为他们教电子工程的全部都是直流设备。我需要研究并找出

这十年到底发生了什么。我知道到 1915 年，他在纽约建立了一个运筹学实验室，并配备了一名工作人员。 1914 年 11 月，他创办了自己的月刊，并获得了邮寄许可证，并且一定正在顺利完成这本书，该书由亨利出版，版权日期为 1916 年。

在本书第一版的致谢中，他特别提到了梅尔维尔·伊斯特姆（Melville Eastham）和克拉普-伊斯特姆（Clapp-Eastham)，他们最初是奥文顿X 射线公司的成员，到 1910 年开始独立运作。将伊斯特姆作为个人提及表明了个人关系，而不是个人关系。一个公司的。因此，也许作为一个 19或20 岁的人，他个人以某种方式参与了这一转变。

我查看了新泽西州、纽约州和马萨诸塞州 1910 年的人口普查记录，但没有找到任何线索；当然，如果他们住在寄宿处，他们就很容易被遗漏。到 1920 年人口普查时，他已经在陆军服役了几年，从事化学战防毒面具材料制造的研究，结婚后在洛杉矶开始了耐火材料制造业务（他的第二个公认的技术能力领域）。

你能想出什么办法来为那些缺失的
1904 年至 1914 年建立一些东西吗？是否有奥文顿或其他人
在 X 射线或高频交流设备领域发表的历史记录可以提供线索？

任何建设性的想法将不胜感激！

KR
汤姆·柯蒂斯

2007 年 9 月 14 日

我采纳了你的建议，在马萨诸塞州的人口普查记录中查找了霍顿教授。
我想我是在 1910 年在沃尔瑟姆找到他的，他被列为在一家学校工作的教师。
上学，44岁，与妻子和岳母住在一起，没有孩子。还在那儿
年减去 MIL。所以也许他是在家里写的文章，或者也许是在
结合他的教学，人口普查对
提供的信息，但姓名包括中间名首字母和职业
看起来不错。

那里仍然没有 TSC 的迹象，我认为寄宿综合症会杀死所有人
机会。

我想如果我们能查出是谁提供了他父亲的 X 射线设备
在1902年或03年，我们可能会在1908年或09年以学徒或初级身份找到TSC
商店助理或工程实习生，一些有寄宿房类型工资的东西
水平。

我很确定那段时间他在波士顿或剑桥的某个地方
一定是一份工作或一个人的承诺证明了这一举动的合理性。
有件事促使他搬离新泽西——他在那里还有家人——
祖父、姨妈和叔叔在那边，还有几位阿姨在那边
母亲的一面。

没有钱会成为离开城镇的动力，他们的房子
在（祖母）去世前居住的地方可能是上流社会
当今社会。市中心，位置显着，非常大，建于
厨师、车夫。我看过一张大约 1932 年的照片，令人印象深刻。
据爸爸说，这一切都进了律师的口袋。有一天我可能会得到
进入遗嘱认证记录，但这只是好奇心，并不能证明
任何东西。

猜测多，事实太少。

韩国

汤姆

2007 年 9 月 23 日

只是偶然发现了一些东西，以你的知识和技能可能是
能够深入挖掘。

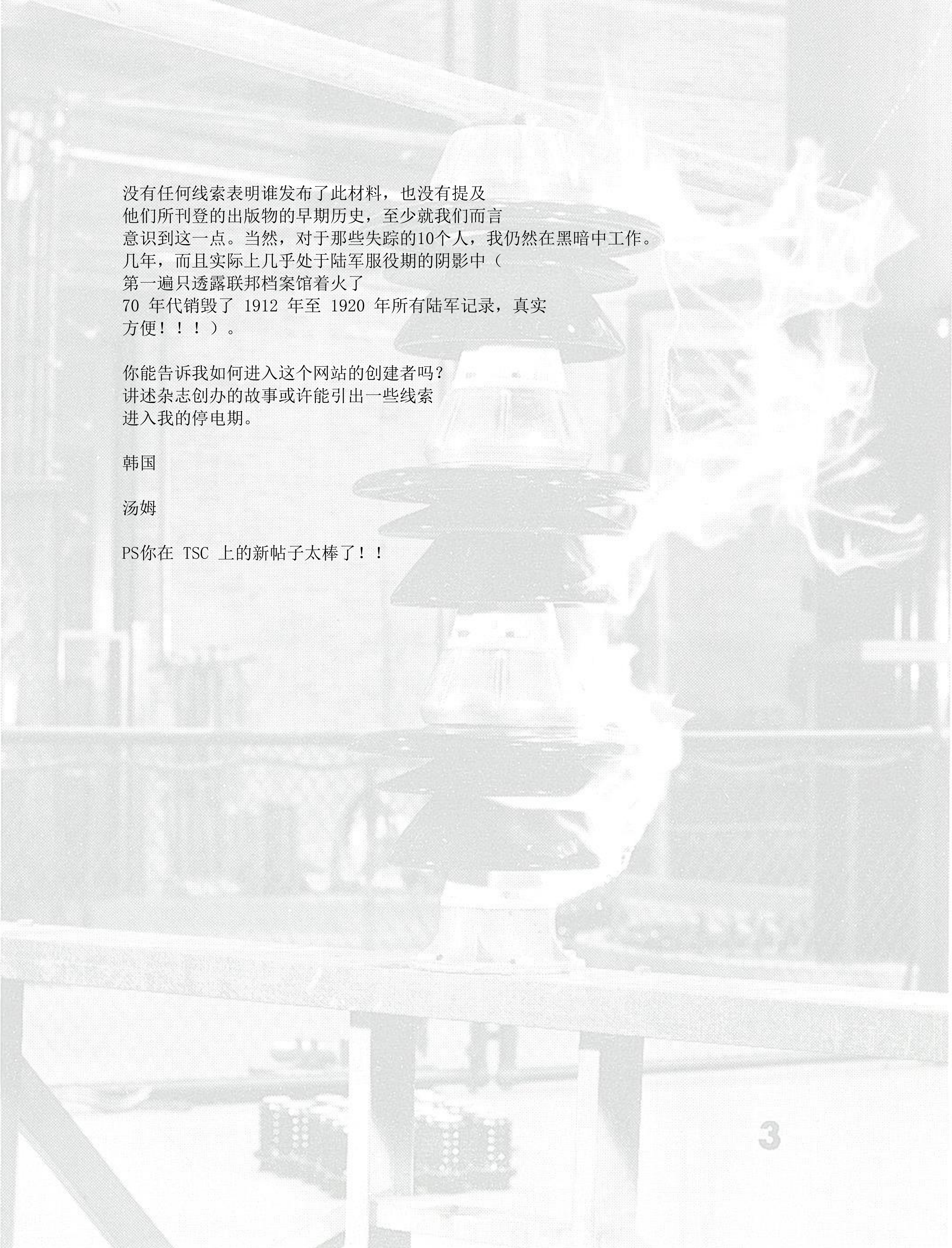
1916 年 4 月至 1917 年 9 月期间，纽约市的 TSC 出版了一份小型报告
月刊。最初该出版物被称为“每日
Mechanics”，由 Everyday Mechanics Co., Inc. 于 2 月出版
1917年刊物名称改为《日常工程》
可能是《大众机械》杂志提起诉讼的结果
（推测，基于一些发表给编辑的信）。 TSC上市
作为编辑，一些熟悉的名字到处出现，比如 Wm 教授。 C
霍顿。

1917年底或1918年初的某个时候，TSC和他的研发团队被“征召入伍”
进入美国陆军化学战部门，致力于解决以下问题
制造防毒面具，或者更确切地说，制造防毒面具所需的电炉产品
罐（活性氧化铝和活性炭）。他确实延长了
寻找活性氧化铝的原材料，
出院后最终带领他前往加利福尼亚州和他的难治性
业务（基于硅酸铝的产品，硅酸铝是活化的副产品
氧化铝生产）。

他离开纽约参军，结束了他对电气的兴趣
设计“如何做”，但该杂志显然以某种方式幸存下来。
他的书 1920 年第二版，在广告部分，有一个广告
为了杂志。

我有一套不完整的杂志第 1 卷第 6 期（9 月）
1916 年）至第 3 卷，1917 年 9 月 6 日）。在第二篇的序言中
该书的编辑雷蒙德·F·耶茨 (Raymond F. Yates) 承认，他的
总的编辑贡献是添加杂志上关于新内容的文章
科目，到书上。

今天早上，我突发奇想，在谷歌上搜索了“日常工程”，找到了很多东西
我惊讶地发现了一个以该名称命名的网站，专门用于出版
1020 流行技术出版物的故事和转载广告
时代。他们展示的第一本杂志封面是 1918 年 12 月号
Everyday Engineering，具有相同的横幅字体和相同的
总体外观，包括 TSC 上一期的 0.10 美元价格。下一个
他们显示的是 1919 年 8 月，即第 7 卷第 5 期，价格已经消失
高达0.15 美元。任何地方都没有显示任何社论材料，只有 AC 的广告
Gilbert（ ErectorSet和几个电气实验套件）。



没有任何线索表明谁发布了此材料，也没有提及
他们所刊登的出版物的早期历史，至少就我们而言
意识到这一点。当然，对于那些失踪的10个人，我仍然在黑暗中工作。
几年，而且实际上几乎处于陆军服役期的阴影中（
第一遍只透露联邦档案馆着火了
70 年代销毁了 1912 年至 1920 年所有陆军记录，真实
方便！！！）。

你能告诉我如何进入这个网站的创建者吗？
讲述杂志创办的故事或许能引出一些线索
进入我的停电期。

韩国

汤姆

PS你在 TSC 上的新帖子太棒了！！